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SCIENCE

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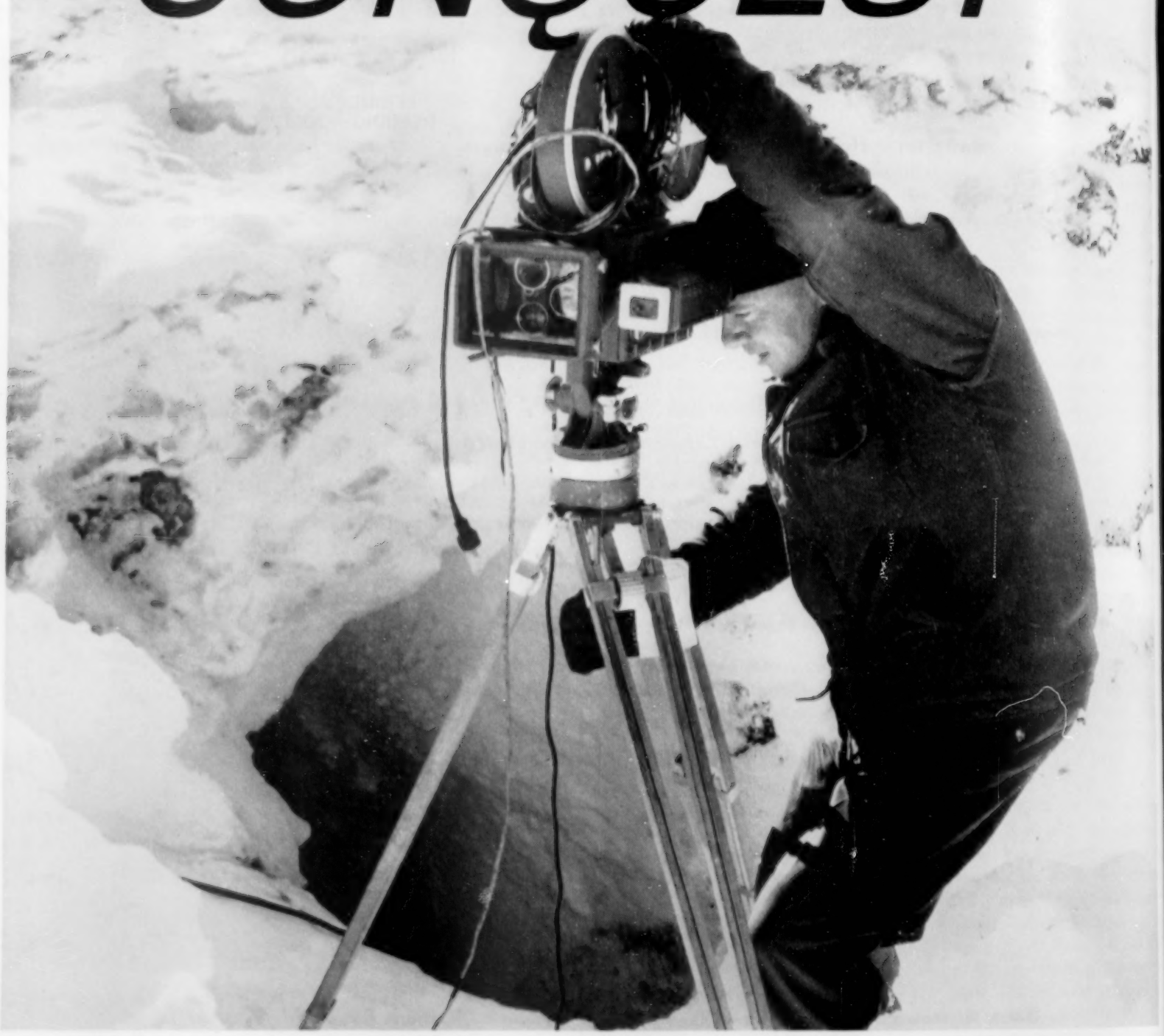

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Height Makes Might

Everyone seems agreed that space science and technology are going to occupy a large place in the Federal Government—the question is where. A variety of government agencies would like to assume responsibility for developing the American space program, with much at stake both for the country and for the agencies. The central issue is the division of tasks between the military and civilian administrations, but there are also jurisdictional disputes within the two camps.

In the Pentagon, to the now familiar struggle among the Army, Navy, and Air Force, a new element is added, the Advance Research Projects Agency. Each of the armed services has something of a claim on the military aspects of space. Presumably, the Advanced Research Projects Agency was created to settle these claims by itself assuming them. The new agency, which is in the Defense Department, has the authority to initiate its own projects in its own facilities, the theory being that when the projects become operational they will be turned over to the appropriate service. In addition, the new agency has Congressional approval to handle nonmilitary aspects of space science for one year. Some critics claim, however, that instead of eliminating competition, the agency will only prove that if three is a crowd, so is four. For the present, according to Defense Secretary Neil H. McElroy, the new agency will limit its activities to reviewing the plans of the armed services, which is the more usual Defense Department procedure.

As to possible outside civilian agencies for space research and development, several proposals are being offered. A bill introduced by Senator Clinton P. Anderson (D.-N.M.) would put the 11-year-old Atomic Energy Commission in charge, while a proposal by the governing body of the National Advisory Committee for Aeronautics recommends that the 43-year-old committee itself engage in astronautical research, in conjunction with certain other existing government scientific agencies. Proponents of both plans point to going complexes of laboratories, and they claim records of successful administration and of close cooperation with the Pentagon. A third proposal is for the establishment of a totally new agency, perhaps along the lines of the A.E.C., or perhaps as a part of a projected Department of Science and Technology. Some observers note, however, that a new agency would have to start from scratch, both in its laboratory and administrative set-ups.

With the conflicting possibilities within and outside the Pentagon, the White House staff is offering recommendations and Congress is moving to consider them. James R. Killian, Jr., the President's assistant for science and technology, and a group of scientists working with him are studying space policy as well as examining a timetable of possible accomplishments. The Senate, following the proposal of Lyndon B. Johnson (D.-Tex.), has created a special 13-member Astronautical and Space Exploration Committee to bring together a variety of bills dealing with the subject. The committee is expected to frame a bill in time for passage this session.

If the developments of science are new, the problems that they raise for the administration of science are not. The successes and failures of the various approaches that have been tried before in this country bear some relation to the present question. With some attention to the lessons of history, we may expect to enter the age of reconnaissance satellites, moon shots, and space travel with sound government policies.—J. T.

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SCIENCE

CURRENT PROBLEMS IN RESEARCH

The Ultrastructure and Function of Bone

Franklin C. McLean

Within recent years there has been an increasing understanding of the nonmechanical functions of bone, and this field is now under intensive cultivation, from many points of view. The present article deals with current trends in research, with special reference to the relation of the fine structure of bone to its function.

The particular function of bone with which this paper is concerned is the role of the skeleton in the homeostatic regulation of the ionic composition of the circulating fluids of the body. It is now clear that the bones serve as a reservoir for the all-important calcium ion, and to some extent for other ions as well. For control of the concentrations of these ions in the blood, which is essential to the maintenance of a steady state in the internal environment, a combination of ion transfer and exchange, in both directions between blood and bone, is in constant operation. Such transfers and exchange are partly purely physicochemical, but they are aided and regulated by biologic processes, including hormonal control and cellular activity.

Current understanding of these processes is dependent upon a variety of experimental approaches to the subject. This paper, while emphasizing the relation of structure and more particularly of fine structure, to function, will draw upon other methods of observation and of experiment, in order, in so far as possible, to present a unified account of the current state of research on the interchanges between blood and bone. Individual statements are not documented, but a short list of references of general interest is appended.

Dr. McLean is an emeritus member of the staff of the department of physiology at the University of Chicago, Chicago, Ill.

Structure of Bone

The most striking characteristic of bone is that it is hard; this hardness results from the deposition, within a soft, organic matrix, of a complex mineral substance, composed chiefly of calcium, phosphate, and carbonate. While the structure of bone, as observed by the light microscope, has been well described for many years, the introduction of new biophysical techniques, such as x-ray diffraction and electron microscopy and the use of radioactive isotopes, has provided much new information concerning the fine structure of both the organic matrix and the mineral of bone and has added to our knowledge of the interrelationships between these components. These newer methods, as well as refinements of those longer in use, continue to give insight into the relation of ultrastructure to function of bone, and they are being actively pursued.

The unit of structure of bone, at the microscopic level, is the haversian system, or osteon. This is, when fully formed, an irregularly cylindrical and branching structure, with thick walls and a narrow lumen, the haversian canal. The canal carries one or more capillaries and venules. The cylindrical osteons are usually oriented in the long axes of the bones, and their basic structure consists of concentric layers, or lamellae, the fibrils of each lamella running spirally to the axis of the canal. The osteon, in addition to its canal and its fibrillar structure, includes large numbers of lacunae, housing the cells of bone (osteocytes) and interconnected with one another and with the lumen by means of branched canalicules. This circulatory system, poor as it may appear, is the only means for transfer of fluids and dissolved substances between the hard tissue of bone and the fluids of the body. In cross section the osteons average approximately 150 microns in external diameter, while the canal may not measure more than 20 microns in diameter. The length of the osteons, however, commonly extends up to several millimeters.

An osteon is formed by deposition of layers, or lamellae, of fibrillar bone matrix on the walls of a cylindrical cavity or tunnel, and subsequent mineralization of these lamellae. After an osteon has been fully mineralized it loses some of its ability to react with the fluids of the body, mainly because its constituents are less accessible to the circulating fluids. Throughout the lifetime of the individual, however, compact bone undergoes a process known as haversian remodeling. This insures the availability of a constant supply of reactive bone, which accounts for less than one percent of the total mass of bone, and it is this reactive bone that gives the skeleton its function as a tissue.

Techniques for Study of Ultrastructure

At the electron-microscope level much information has been obtained concerning the fibrillar structure of bone and the characteristics of collagen fibers, as well as about the form of the crystals of the bone mineral and their relation-

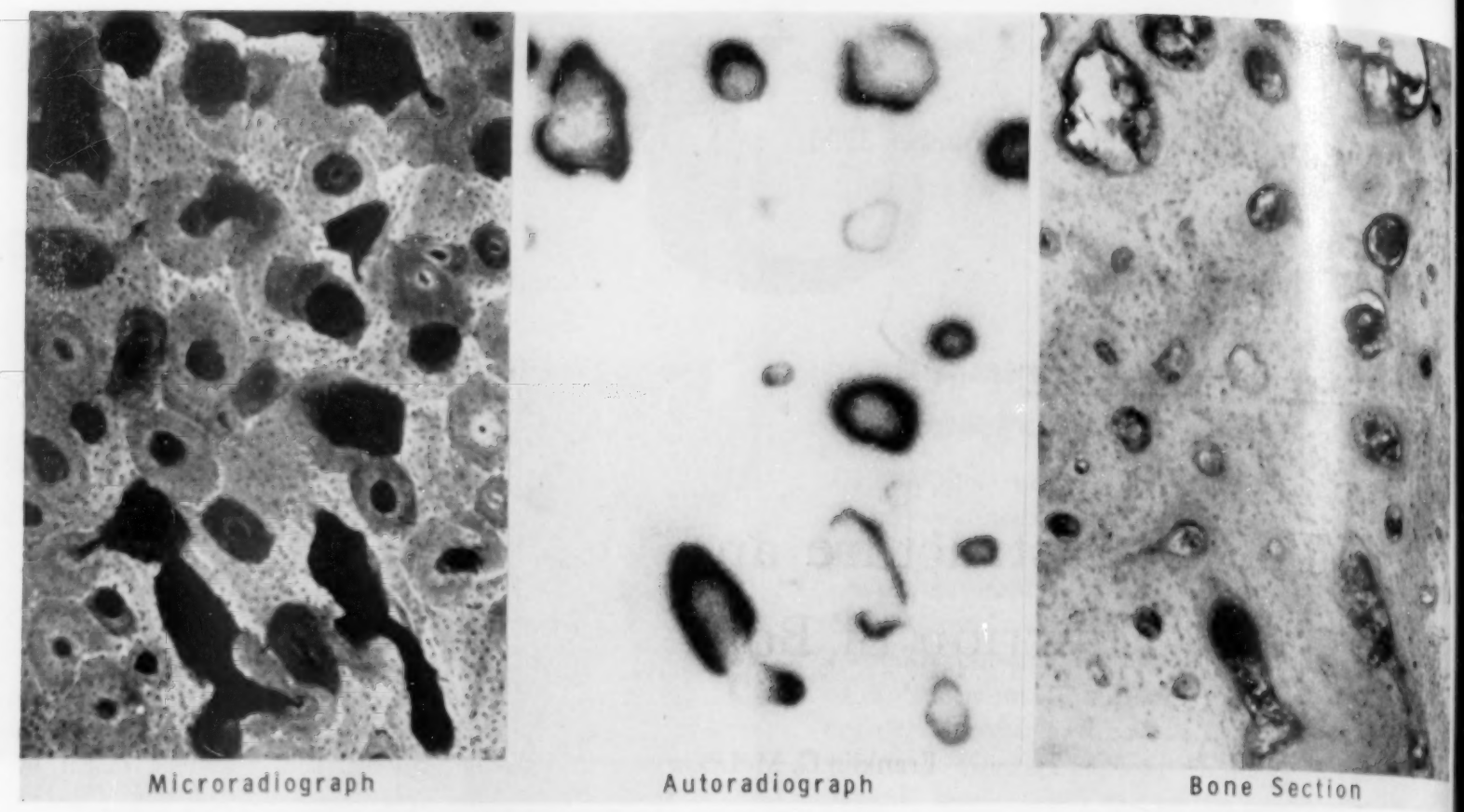

Fig. 1. Microradiograph, autoradiograph, and photomicrograph of the same section, from the shaft of the tibia of a young adult dog, sacrificed two weeks after intravenous administration of 250 microcuries of strontium-90 per kilogram. Undecalcified, unstained, ground transverse section (×62). [Courtesy of Jenifer Jowsey].

ship to the collagen fibers and to the ground substance. A beginning has been made on the ultrastructure of ground substance, until recently described as amorphous. The potentialities of the electron microscope for elucidating the fine structure of bone, and thus permitting further insight into its functions, have by no means been exhausted.

Electron microscopy of bone has been aided by x-ray diffraction, both high-angle and low-angle. High-angle diffraction, particularly with microdiffraction techniques, has been of much assistance in studying the crystallographic properties of bone tissue. Low-angle diffraction has given information about the dimensions of the particles and their orientation.

Microradiography requires the passing of x-rays through thin sections and the recording of differences in absorption of the radiation on photographic film, thus permitting enlargement of the image. Application of this technique to bone has given results of great interest. Whereas ordinary histologic sections of bone do not reveal differences in the density of individual osteons, such differences are clearly demonstrated in microradiograms, the younger osteons being less mineralized, and consequently less dense than the older ones. This has focused attention on the mineralization of osteons, and it is readily demonstrable that the new and less dense osteons account for most of the uptake of radioactive calcium, strontium, and phosphorus.

When a radioisotope—for example, strontium-90—has been administered to an animal and undecalcified sections of bone have been made, it is possible to prepare photomicrographs, microradiograms, and autoradiograms, all of the same section. These may be enlarged to the same size and compared (Fig. 1). The radioisotope is not only taken up chiefly by the newer and less dense osteons; by far the greater portion of it is taken up by a thin layer of new and only slightly mineralized matrix, which may not be seen at all in microradiograms, but which may be visible in the section under the light microscope. When this layer is absent, no appreciable amount of radioisotope may be taken up by a particular osteon, even though the osteon as a whole may be incompletely mineralized, and hence of a density comparable with others which do take up the isotope. These combined techniques afford a record of the sequence of events in the growth and mineralization of bone, not seen by any one of the techniques alone.

The results obtained on normal bone tissue by microradiography have been confirmed by microinterferometry. In addition, microinterferometric measurements made on decalcified sections have shown that the content of organic material varies but little from one osteon to another, indicating that the differences seen on microradiographs depend solely upon the degree of mineralization. The polarizing microscope also gives new and valuable information about the ultrastructural organization of calcified tissues.

Organic Matrix of Bone

Collagen. Collagen is a fibrous protein, common to all forms of connective tissue. Most of the protein present in bone is collagen, which is responsible for about 95 percent of the dry fat-free organic content. It occurs in fibers about 800 angstroms wide, of indeterminate length, characterized by dense cross-banding at intervals averaging about 640 angstroms, and is generally oriented in the long axes of the bones. It is in an organic crystalline form, capable of refracting x-rays. In addition to a wide-angle pattern, it gives a low-angle pattern with a fundamental repeating unit of about 660 angstroms; this is in good agreement with the cross-banding observed with the electron microscope.

Collagen from certain sources, such as rats' tail tendon, can be dissolved and reconstituted by appropriate treatment. When reconstituted it may assume one

of a number of forms, according to the method of treatment, including the native form as seen in connective tissue. From electron microscopic observations it is believed that bone collagen is secreted by osteoblasts—the bone-making cells—in soluble form as molecular units, with the capability of self-aggregation.

Ground substance. The remainder of the organic matter of bone, slightly less than 5 percent, is termed the "ground substance"; it fills the spaces between the collagen fibers and the crystals of bone mineral. In connective tissue in general, ground substance has commonly been described as amorphous, but recent electron microscopic observations indicate that it has an organization and ultrastructure of its own. It varies in consistency from that of the interstitial fluid to that of the basement membrane. It is coextensive with both; they represent its fluid and condensed portions, respectively. The interconnection of the ground substance with the tissue fluid, by virtue of which the two exist as a continuum, permits exchange of ions and other substances with the blood. Chemically the ground substance consists of protein and carbohydrates, some of which exist as polymers of glucuronic acid and hexosamines, in both sulfated and unsulfated forms.

Mineral of Bone

Ultrastructure. There have been differences, not wholly resolved, in the reports of the form of the crystals of bone mineral. All observers are agreed that the crystals are extremely minute, and estimates of the dimensions vary only within comparatively narrow limits. The crystals have been described as hexagonal tabular forms, of variable size, but in general only a few hundred angstroms in length and breadth, and with a thickness of only a few unit cells, averaging a total of perhaps 20 to 50 angstroms. Low-angle x-ray diffraction results have been interpreted to indicate that the crystals are rods or hexagonal prisms, about 200 angstroms long and 75 angstroms in diameter. That the crystals are rod- or needle-shaped, with a length of 200 to 700 angstroms and a diameter of 30 to 50 angstroms has been the finding most commonly reported, from electron microscopy, in recent publications. All of these findings are in agreement about the tremendous surfaces of the crystals in relation to their mass and about the importance of surface phenomena in determining the composition and reactivity of the mineral phase of bone.

A subject of much current interest is the interrelationship between the collagen fibers, with their cross-banding, and the mineral of bone. It has been suggested, but not proved, that the collagen fibers, or some part of them, are responsible for seeding and thereby initiating the deposition of the crystals of hydroxyapatite, perhaps by the phenomenon known as epitaxy. A variant of this is the proposal that the mechanism of nucleation involves a specific stereochemical configuration resulting from a particular state of aggregation of collagen macromolecules. In any event it is clear that the long axes of the crystals are commonly oriented in the long axes of the collagen fibers, that they are arranged for the most part around the fibers or fibrils, forming a sort of a sheath, and that they have a special relationship to the cross-banding.

Small particles, approximately 100 angstroms in diameter, with no preferred orientation relative to the fibril axis, have been described between the bands in the earliest stage of calcification. In fully calcified bone the crystals, oriented in the fibril axis, tend to form bands around the collagen fibrils, leaving gaps, as observed with the electron microscope, between the bands (Fig. 2); these gaps correspond to the spacing of the collagen fibrils between the periodic cross bands. In some instances the crystals are long enough to span two or more major periods, obscuring the fiber period. The question of the possibility of crystalline or amorphous mineral substance, situated *within* the collagen fibers, remains undecided. The close physical association between the fibers and the crystals of bone mineral lends weight to the belief that there is a chemical interaction between the two phases; it has been proposed that the close association of the organic matrix with the crystals serves to preserve an instability in crystal structure, responsible for the reactivity of the crystals.

Chemistry. Despite intensive efforts over the past century, and despite the great advances made in recent years, the chemistry, dynamics, and ultrastructure of bone mineral remains a fertile field for inquiry.

It is now firmly established, by x-ray diffraction and by other methods, that the bone salt belongs to the apatite series of minerals, of which the prototype is fluorapatite:

$$3Ca_3(PO_4)_2 \cdot CaF_2,$$

which is abundant in nature. The weight of evidence is to the effect that the crystalline material found in bone corresponds most closely to hydroxyapatite:

$$3Ca_3(PO_4)_2 \cdot Ca(OH)_2$$

although there are differences in interpretation of the evidence now available. While the bone mineral contains considerable amounts of carbonate and citrate, current opinion is to the effect that these substances are related to the

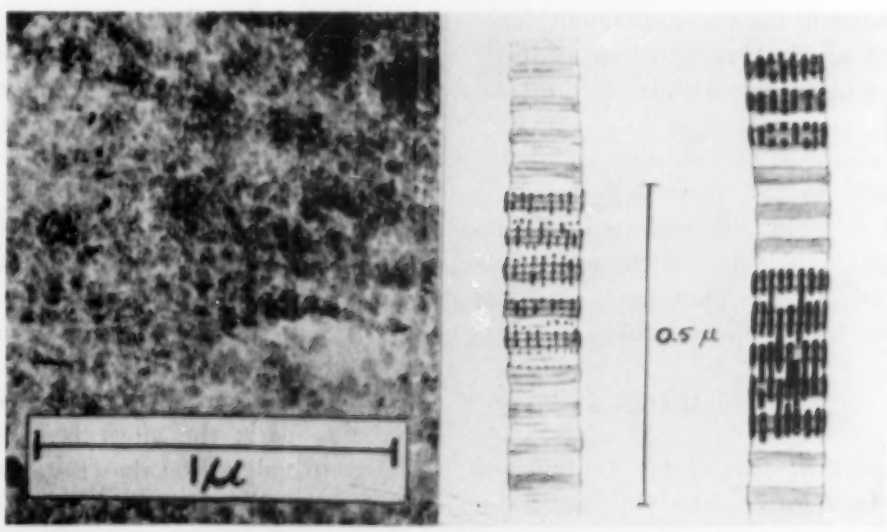

Fig. 2. (Left) Electron micrograph of a section of an undecalcified human rib, illustrating the pattern of arrangement of crystals of bone mineral in relation to collagen fibers. The underlying collagen is barely visible, but the crystals are easily seen in the regularly arranged bands corresponding to the main collagen striation. The longitudinal direction of the fibers is horizontal. [From Fig. 1, W. F. Neuman and M. W. Neuman, *Chem. Revs.* **53**, 4 (1953) (courtesy of R. A. Robinson and M. L. Watson). Reproduced by courtesy of Williams and Wilkins Co.] (Right) Course of calcification in bone matrix, showing the relation of inorganic crystals to cross banding of collagen fibers. [From Fig. 21, R. A. Robinson and M. L. Watson, *Ann. N.Y. Acad. Sci.* **60**, 620 (1955). Reproduced by courtesy of the publishers.]

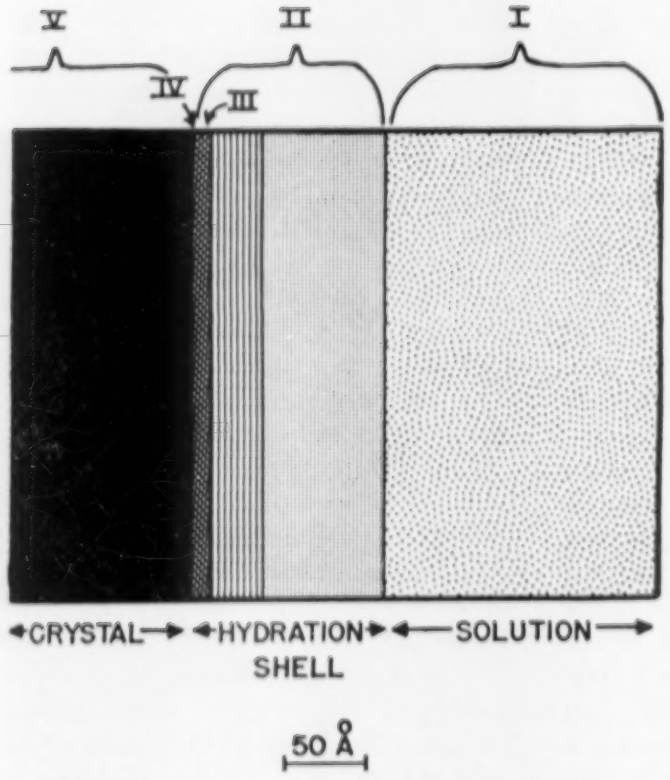

Fig. 3. Diagrammatic representation of the crystal-solution interface. I, the bulk solution (intercellular fluid): II, the hydration shell, comprised of three layers — loosely held water, tightly bound water, and the hydrated ion layer (III); IV, the lattice surface; and V, the crystal interior. [From Fig. 1, W. F. Neuman and M. W. Neuman, *Am. J. Med.* **22**, 124 (1957). Reproduced by courtesy of the publishers.]

surfaces of the crystals of hydroxyapatite and that they are not part of the lattice structure. The small amounts of such ions as Na^+, K^+, Mg^{++}, Cl^-, and F^- found in the mineral are regarded as impurities, resulting from the formation of the mineral from the body fluids, from which these ions are deposited during the process of crystallization. More difficult to account for is the fact that the molar ratio Ca/P, theoretically 1.66, varies from 1.3 to 2.0 in a series of solid calcium phosphates which give the characteristic apatite lattice pattern on x-ray diffraction. This variation is now attributed to the extremely small size of the crystals and to the correspondingly large influence of the contributions of their surface ions to the analyses of the total mineral.

The school of Dallemagne still holds tenaciously to the view that the bone mineral is essentially hydrated calcium triphosphate, which Dallemagne terms alpha tricalcium phosphate, and to which he assigns the formula

$$3Ca_3(PO_4)_2 \cdot H_2(OH)_2$$

In support of this thesis Dallemagne now brings forth data obtained from observation of ion-exchange reactions, which he interprets to indicate (i) that the mineral of living bone is in an unstable form; (ii) that it is kept in this unstable form by its close association with the organic matrix; (iii) that the characteristics responsible for its instability are also responsible for its reactivity in the living organism; and (iv) that on removal from the bone, except under very special precautions, it is transformed into the stable hydroxyapatite, which then is identical with preparations of this mineral prepared synthetically.

Crystal complex. An understanding of the phenomena of ion transfer or ion exchange between the crystals of bone mineral and the circulating fluids of the body requires as accurate information as possible concerning the ultrastructure of the reactive crystals and of their surroundings. The descriptions here used are derived from those of Neuman and Neuman. It is convenient to regard the unit of the mineral of bone, at the ultrastructural level, as a crystal complex, each such complex being based upon a microcrystal of colloidal dimensions, only a few hundred angstroms in length and with a thickness of only 20 to 50 angstroms. Owing to their minute size, these crystals have an enormous surface per unit of mass—of the order of 200 to 300 square meters per gram. Each ion held on the surface of the crystal is surrounded by oppositely charged ions *on one side only*; the effect is a residual charge or valency on the crystal surface. Because of their small size, these crystals can attain greater stability almost exclusively by chemisorption; this leads to a highly variable surface composition. It results also in increased reactivity of the crystal complex. Around the crystal and partly bound to its surface there are also a layer of hydrated ions and a shell of water which may exceed the dimensions of the crystal itself. Synthetic apatite crystals, for example, may bind 0.4 gram of water per gram of crystals; because of the difference in density, this represents a volume of water greater than that of the crystals.

Each crystal complex, therefore, where adequate hydration is possible, may be viewed as a series of layers, as illustrated in Fig. 3. Any ion from the surrounding fluids can diffuse into the outer layers of the hydration shell. At the crystal surface there is a bound layer of hydrated calcium, phosphate, and hydroxyl ions, constantly interchanging with similar ions in the surface layers of the lattice. Owing to vacant lattice positions there is also a constant though much slower ion interchange within the crystal itself. Of the ions in the fluids of the body, some can penetrate the hydration shell only (K^+ and Cl^-), some can penetrate the surface-bound ion layer of the lattice surface by displacing calcium, phosphate, or hydroxyl ions (Na^+, UO_2^{++}, CO_3^{--} and citrate^{-3}) and some can pentrate still further—that is, into the crystal interior (Ca^{++}, Sr^{++}, Ra^{++}, PO_4^{-3}, F^-). All of the possible ion transfers and movements may be assumed to be of constant occurrence wherever the fluids of the body are in close contact with the crystal complex of reactive mineral.

In contrast, as the crystals age, and as they increase in numbers, they gradually displace the water essential to their reactivity, until eventually there remains a solid, inert, almost unhydrated mass of crystals and fibers, incapable of more than a very slight degree of ion exchange or transfer with the fluids of the body. Such stable bone tissue makes up more than 99 percent of the mass of compact bone, and it can be made available to the organism as a whole only by cellular action, resulting in resorption. This conversion of reactive to nonreactive bone, which is a necessary concomitant of mineralization of the organic matrix, would eventually lead to a skeleton composed entirely of stable mineral—a condition incompatible with the life of the organism—were it not for the constant haversian remodeling of compact bone that continues throughout the life of the individual. In this respect the state of the mineral of bone differs sharply from that of most mineral deposits in nature; a condition of instability is a *sine qua non* of life; stability of the bone mineral, as well as of other components of the body, is a state that can be attained only after the death of the organism.

Dynamic aspects. A kinetic approach

to the interchange of ions, more especially of calcium and phosphate, between blood and bone, has been made possible in recent years by the introduction of radioisotopes. Not until the first papers appeared from Hevesy and his group in 1935, describing the behavior of radioactive phosphorus, phosphorus-32, administered to animals as inorganic phosphate, was it possible to appreciate the magnitude of the rate of turnover of skeletal phosphorus. Owing to the more limited availability of calcium-45, demonstration of its uptake by the skeleton was delayed until 1940, and in fact it was not until after 1948 that calcium-45 could be used in biological work in quantities adequate for the elucidation of the many problems relating to calcium metabolism. Still more recently a beginning has been made in Sweden with calcium-47, which is as yet not in general use; because of its short half-life and high-energy gamma radiation, it can be traced by external counting methods, and used safely in man. Strontium-85, with much the same properties, is available and has been used more extensively, but since the body discriminates between calcium and strontium the latter is not an entirely reliable indicator of the behavior of calcium.

The use of radioisotopes has not yet progressed to the level of ultrastructure. Calcium-45 and phosphorus-32 have been used for evaluation of over-all accretion, resorption, and exchange reactions in the skeleton and they have made possible quantitative estimates of the relative magnitudes of these processes, thereby throwing light on their physiologic significance. With the use of strontium-85, the application of external counting methods, and the employment of an electronic analog computer, the principles of the studies made in animals have been extended to man. Exponential analysis of the data obtained has made it possible to study rates of movement of the isotope between four compartments (serum, extracellular fluid, intracellular fluid, and bone). Similar studies, with improved equipment and using calcium-47, are now under way and are opening a wide field for further investigation.

Homeostatic Control of Calcium Ion Concentration in the Blood

The maintenance of an approximately constant concentration of the physiologically active form of calcium, the calcium ion, in the circulating fluids of the body is essential to life. Among other physiologic activities, the calcium ion, in an appropriate concentration, is essential to the heart beat, to the coagulation of blood, and to the proper functioning of nerve tissue.

It has been known for some years that the parathyroid glands, four tiny bodies embedded in the posterior surface of the thyroid gland, play a decisive role in the regulation of the calcium ion concentration in the blood plasma. Only within recent years, however, have the details of this mechanism begun to be fully understood, and certain aspects of it are still under intensive study. These glands and their functions may be regarded as analogous to the thermostatic control of the temperature of a house. Thus the parathyroid glands are sensitive to the concentration of calcium ions in the blood; a deficiency in calcium ions leads to increased activity of the glands, while an excess leads to decreased activity (Fig. 4). In recent years such self-regulating processes have acquired the name "feedback." The condition that is being regulated is itself the stimulus activating the regulatory mechanism; information about the output is fed back to an earlier stage of the process so as to influence its action and thereby control the output. Feedback is being increasingly made use of in industrial processes; the living organism is dependent upon a multitude of such built-in feedback mechanisms.

Once it was established, only a generation or so ago, that the parathyroid glands regulate the release of calcium from the bones into the blood, it was commonly believed that this relatively slow-acting process was adequate to maintain a physiologic level of calcium ions in the blood plasma. This belief was strengthened by the fact that removal of the parathyroid glands leads to a lower concentration of calcium ions in the plasma, while hyperparathyroidism, or

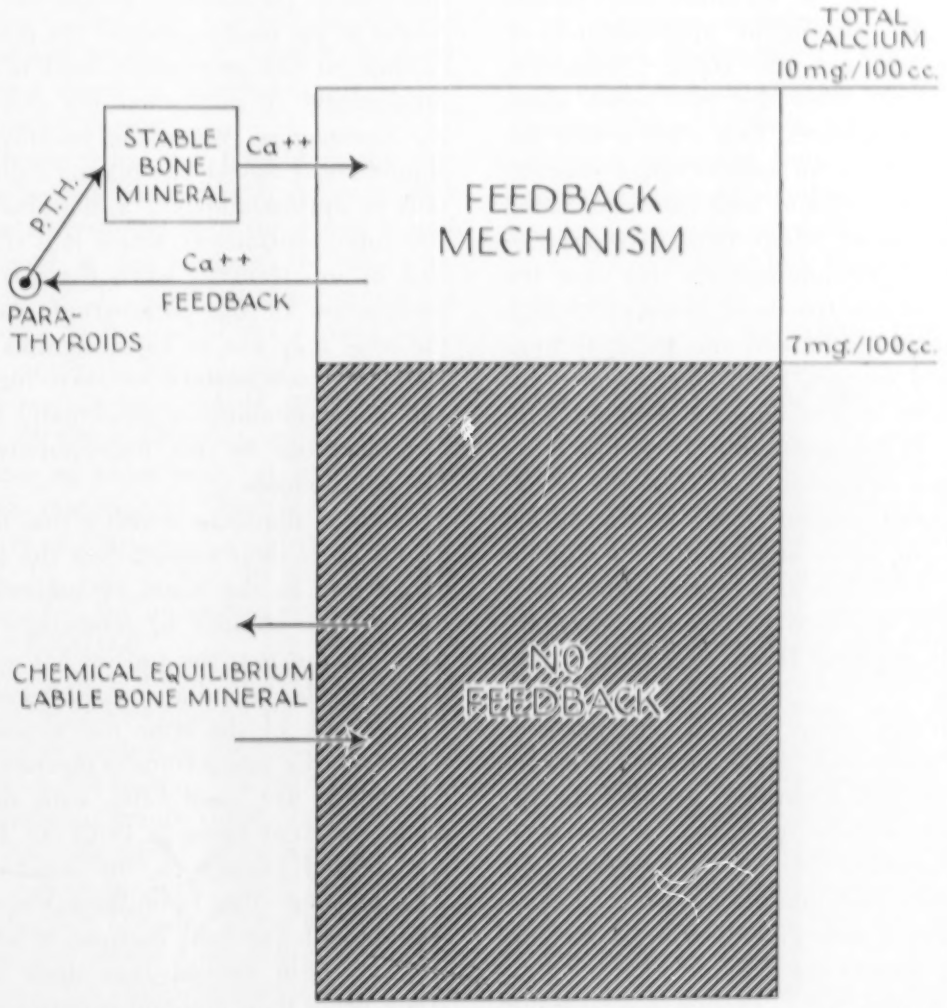

Fig. 4. Diagram illustrating the mechanism of exchange of calcium between blood plasma and bones. Rapidly acting equilibrium with the labile fraction of bone mineral is independent of the parathyroid glands and is adequate to maintain the plasma calcium level at approximately 7 milligrams per 100 cubic centimeters. Parathyroid activity is under control of feedback from Ca^{++} concentration in the plasma and regulates the slower release of calcium from stable hydroxyapatite crystals of bone mineral. The parathyroid glands monitor the calcium concentration of the plasma and maintain it at approximately 10 milligrams per 100 cubic centimeters. [From Fig. 14, F. C. McLean and M. R. Urist, *Bone* (Univ. of Chicago Press, Chicago, Ill., 1955), p. 77. Reproduced by courtesy of the publishers.]

administration of the parathyroid hormone, leads to a higher concentration of calcium ions. Introduction of tracer methods, however, and increasing understanding of the internal structure of bone have made it clear that the parathyroid mechanism, while responsible for hour-to-hour or day-to-day adjustments, is not alone adequate for the minute-to-minute interplay between blood and bone. Especially revealing in this respect is the demonstration that, in young animals, the turnover of the blood calcium may amount to as much as 100 percent per minute, which is to say that the equivalent of the total amount of calcium in the blood may be replaced every minute.

In order to account for this rapid turnover, it is necessary to postulate a "dual mechanism" for homeostatic control. One part, which acts rapidly, requires ion transfer or ion exchange between blood and bone and is independent of the function of the parathyroid glands, being able in the absence of these glands to maintain the plasma level of calcium at approximately 7 milligrams per 100 cubic centimeters. At present there are two views about how this operates. One view is that the bone acts as an ion-exchange column, taking up calcium ions from the blood and returning others, by passive physicochemical mechanisms. By this view the labile or reactive bone mineral, or that in the newly formed and partially mineralized osteons, is in equilibrium with the ions in the fluids in contact with them. If the equilibrium is disturbed, by removal of calcium ions from the blood, additional calcium ions are transferred from the labile stores until the physiologic level has again been reached; if calcium is added to the blood, the excess is promptly transferred to the labile stores.

Another view is that this transfer mechanism may itself involve intervention by cell activity, at least in the direction of bone to blood. It has been demonstrated that both the parathyroid hormone and vitamin D, which appear to have a synergistic action in this respect, control the concentration of citric acid in the bones, presumably by influencing its formation by the cells of bone. It is then contended that the citric acid acts to carry calcium into the blood stream, by forming soluble calcium-citrate complexes, and that following this the citrate ion is metabolized in soft tissues, thus leaving the calcium in the blood. It is possible that both passive ion transfer and a mechanism depending upon citric acid formation, under the control of the parathyroid hormone and of vitamin D, operate to influence the rapid exchange of calcium between blood and bone. In any case, the transfer of ions that takes place over periods of seconds or minutes now seems to be definitely localized in the accessible, labile, and reactive bone in the new and incompletely mineralized osteons.

The possible role of the parathyroid glands in mediating this rapid transfer of mineral from bone to blood, by control of the production of citrate, cannot now be regarded as fully established. The function of the parathyroid glands with respect to the dual mechanism is, however, better understood, at least in its outward manifestations. Normally functioning parathyroid glands are essential to the maintenance of the plasma calcium at the physiologic level of approximately 10 milligrams per 100 cubic centimeters. When the parathyroid glands are removed, the plasma calcium falls to approximately 7 milligrams per 100 cubic centimeters, where it is stabilized by ion transfer; when there is hyperfunction of the parathyroid glands, the level may rise to 15 milligrams per 100 cubic centimeters, or even higher, and be maintained at abnormally high concentrations by the hyperactivity of the parathyroids.

There is abundant evidence that these glands exert their control over the level of calcium in the blood by influencing the solution of bone by osteoclastic resorption, and that this process has access to the stable, fully mineralized bone, or to the bulk of the bone not accessible to the rapidly acting transfer mechanism. Osteoclasts are giant cells, with many nuclei, often as many as 15 or 20. They are located mainly on the inner surfaces of bone—that is, on the surfaces in contact with the bone marrow. While it has not been proved that these cells erode bone, their constant occurrence in areas where resorption is taking place, together with the associated histologic picture, "suggest that their presence is more than incidental." Administration of parathyroid extract to animals leads to greatly accelerated resorption of bone, usually associated with large numbers of osteoclasts; parathyroid control of resorption is well established, even though osteoclastic participation is still conjectural.

To fit these pieces together, we may visualize the two parts of the dual mechanism, as illustrated in Fig. 4, as follows. (i) The parathyroid glands are responsible for monitoring the calcium ion concentration in the blood plasma. They respond, rather slowly, to changes in the calcium ion concentration in the internal environment, and by regulating the dissolution of stable bone mineral they serve to maintain a relatively constant level of calcium ions in the blood. (ii) What we may call the fine adjustment of the calcium ion concentration in the blood—that is, the minute-to-minute control—is effected by rapid transfers, in both directions, between the blood and the labile fraction of the bone mineral. Whether this is a purely passive chemical affair, by diffusion equilibrium, or whether it also is mediated by the parathyroid hormone (as well as by vitamin D) remains uncertain. Whatever may be the intimate details of this part of the mechanism, and however it may be related to the ultrastructure of bone, it is essential to the continued life and health of the organism, which without it would be subject to violent fluctuations in the levels of calcium ion concentration in the internal environment.

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Foreign Aid and Agricultural Science

Leopoldo B. Uichanco

For some reason, certain Filipino leaders have recently taken a critical view of the American aid program in the Philippines. So far as I can gather, the principal bases for the criticism are: (i) the total amount spent in dollars is disproportionately small in relation to the counterpart peso funds (two pesos equal one dollar); (ii) much of the peso expenditure is used for the benefit of American experts; (iii) in not a few cases, these so-called experts are not really experts at all, but people with relatively little training and experience; and (iv) the program apparently aims to shackle the Philippines to an agricultural economy, as is shown by its overemphasis on agriculture, at the expense of industry.

It should be pointed out that the United States Congress on its part has also been showing uneasiness toward the foreign aid program because of the adverse criticisms voiced by, and the heavy burden the program imposes on, the American taxpayer.

Without attempting to refute the arguments advanced, I wish to relate our experience in the operation of what is presently known as the ICA–NEC (International Cooperation Administration–National Economic Council) program in the College of Agriculture of the University of the Philippines at Los Baños. The International Cooperation Administration is the United States agency which carries out programs of economic development and technical cooperation in many of the less-developed nations of the world. The National Economic Council is the national economic planning and coordinating center for the Philippine Government.

War Destroys College

World War II left the College of Agriculture and its Central Experiment Station in shambles. Most of the buildings were in ruins and nearly all the animals, seeds, tools, equipment, laboratory apparatus, and library were either destroyed or looted. Although brave attempts were made to reopen the college to students in June 1945, while the rest of the university was still closed, almost no facilities were extant, and emergency shelter for faculty and students had to be found temporarily in old poultry laying houses. Indeed, about the only asset of the college that was left was the experienced faculty that, happily, escaped general massacre on the campus by the retreating enemy.

Prospects for ever rebuilding the college looked bleak. We had but a dim hope of restoring it to the status it had attained at the outbreak of the war, when, in 32 years, it had grown in prestige to be one of the world's leading tropical agricultural institutions. The war damage awards to the University of the Philippines, which came a couple of years later, at first gave us some reassurance. However, this new source of relief was to prove quite elusive, for out of the 10 million pesos granted to the university, we were given only P.400,000.

When what is now the ICA–NEC program began to operate in 1952, things began to happen in the College of Agriculture. We became the happy recipient of generous grants, thanks largely to the previous flattering recommendations of the American Agricultural Mission and of the Bell Mission. These two missions were sent by the United States Government to the Philippines after World War II to study the needs of the country and to make recommendations to meet those needs. An important feature of the program was the contract for technical assistance signed between the University of the Philippines College of Agriculture at Los Baños and Cornell University.

Technical Assistance Teams

As a result of this contract, which will continue until 1960, a succession of teams of not more than ten American professors (later increased to 14) have been assigned to the college, each to be in residence here for not less than one year. In practice, some visiting professors found the work so interesting and challenging that they stayed about two years. Thus, during the past five years, we had the privilege of having on our faculty, in succession, 34 American professors. Many of them were top-ranking in their lines of specialization. Of the 13 in residence during the past year, three were department heads and one, an associate dean. Three professors are mainly supported by grants from the Council on Economic and Cultural Affairs, which has its headquarters in New York City.

Dean W. I. Myers and his colleagues at Cornell University have been so justifiably proud of their part in the Los Baños program that they have always taken great care to select only high-grade men for assignment here. They have drawn heavily on the Cornell faculty, even at some sacrifice to that institution. Some of these visiting professors were borrowed from other American universities. As an added precaution, the record of each candidate for assignment is first sent to Los Baños for scrutiny and approval.

The salaries of the visiting professors are paid, in dollars, from the International Cooperation Administration headquarters in Washington. Because these are ranking men on their respective faculties, the annual bill settled by Washington in salaries alone is considerable. The International Cooperation Administration, Washington, also pays the transportation and living and other allowances for our College of Agriculture faculty members who are sent abroad for advanced training. Every year about ten Filipino faculty members could avail themselves of this privilege, and to date 54 have been sent. Most obtained advanced degrees and have become valuable permanent assets to the college faculty.

Against these Washington expenditures, which total about a million pesos a year, our counterpart in the college for the support of the Cornell contract is only about P.200,000 a year, to meet transportation costs, living expenses,

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Fig. 1. Through these gates of the University of the Philippines College of Agriculture, at Los Baños, pass 3000 students who are unbelievably eager for a college education. In addition, the college serves as a training center for students from other Southeast Asian countries.

utility allowance, cost-of-living expenses, and per diems of the visiting professors and their families. The per diems for members of the family are paid only in connection with actual travel between the college and their respective residences in the United States. Of course, much larger peso allocations than this have been made to the college under the ICA–NEC program, but not a centavo of these additional sums has been spent for the visiting American professors. They have been used for improving the facilities; for hiring additional Filipino faculty members, research assistants, and technicians; for constructing more laboratory and classroom buildings and residences; for acquiring laboratory and farm equipment, and for purchasing livestock, increasing library facilities, and introducing numerous other improvements.

Close Working Relationships

As a result of this aid, in physical and faculty assets the college is at present very much better off in many respects than ever before in its 48 years of life.

The American faculty members do not function separately as an American group; they are members of the college departments to which they are assigned. The working relationship has certainly never been that of the American scientist and his native assistant, as was unfortunately the humiliating experience in this country even after World War I, which had allegedly been waged to "save the world for Democracy." American and Filipino have now happily worked as colleagues in Los Baños, where one is not the teacher and the other the perennial pupil; they have collaborated closely, studied together, and learned from each other. Even the members of their families have considered themselves a part of the local community, and their children have studied and genuinely enjoyed their experience in the same schools with the Filipino children, with whom they have developed lasting friendship and mutual respect.

Large Student Enrollment

Mainly as a result of the partnership between Cornell and Los Baños, the past five years have seen phenomenal growth in the College of Agriculture. From an average of 500 students, enrollment rose rapidly until it spiralled to over 4000 in 1955. Subsequently, limitations on new admissions had to be imposed by the faculty in an effort to safeguard standards. At present, the student body is held down to about 3000 (Fig. 1). Even this is somewhat too many for the capacity of the faculty, of only about 200, and of the facilities, but this number is deemed necessary to produce an estimated 300 graduates a year and to meet the growing requirements of the country in agricultural services.

The college is again steadily attracting students from neighboring countries, as it did before the war, and Washington and private American foundations have come to regard the college as a training center in agriculture for Southeast Asia. At present, we have 53 students from four foreign countries.

Likewise, various important government units and private concerns that deal with agricultural development and promotion have sent their men to the college for in-service training. The principal training center of the Community Development Program, under the Office

Fig. 2. The author (right) discusses the building of a new International House on the College of Agriculture campus with John D. Rockefeller III. The Rockefeller Foundation has made a grant of $250,000 (P.500,000) for this purpose.

of the President of the Philippines, is located on the college campus, where the faculty is actively cooperating.

Generous allocations by the Council on Economic and Cultural Affairs and the Rockefeller Foundation have been earmarked for the support of East Asian students in the college and for the following additional purposes: to engage certain highly qualified American professors; to upgrade library, classroom, and laboratory facilities; to help some deserving young faculty members to take up graduate studies in the United States; and to enable a limited number to make study tours abroad or attend international conferences. Recently, the Rockefeller Foundation likewise made a sizable grant of half a million pesos to establish and maintain an International House on the campus (Fig. 2). Local government and private entities have also made grants, largely for research and graduate scholarships.

Research Program Fostered

Research has always been given due emphasis by the faculty of the college, from the beginning of its life, because of the strong feeling that no one can be an effective teacher who is not at the same time an active researcher. Otherwise, the subject matter he imparts could grow stale and flat as he merely parrots borrowed ideas which are not constantly freshened and enlivened by first-hand contact with natural processes. Also, the faculty has been conscious of the fact that the Philippines is not a rich country because agriculture, on which its economy is based, has remained quite weak.

As has been the experience in other lands, it has been found that high agricultural productivity cannot be attained unless a sustained research program is fostered to solve numerous problems which serve to depress farm income. Of paramount importance is the fact that research enthusiasm is contagious, and the teacher-researcher quickly imbues his students with the desire to find out things for themselves and to develop the creative spirit of a scholarly mind.

Unfortunately, research funds, in the past, were perennially short. In 1918, the Legislature voted and made available the sum of P.125,000 for establishment of the Central Experiment Station in the College of Agriculture. The funds went into the purchase of additional lands, which enlarged the college area from the originally very inadequate 70 hectares to a much more capacious 400 hectares. A more adequate stock of farm animals was acquired, and farm implements were purchased.

Sad to relate, the Experiment Station was to be quickly forgotten, and no continuing support was to be forthcoming. Hence, whatever research could be done was carried out through the meager sums that had been squeezed out of the slim funds intended primarily for educational purposes. Creative scholarship was maintained largely on the spare time or overtime of the faculty and of the more advanced students.

These conditions should have disheartened any but the most determined; they are related here not to offer an excuse for limited accomplishment. When one looks back, the wonder indeed is that the faculty and students could make any contribution at all. Despite tremendous odds, the annual research output of the college rose progressively, and much of the basic foundation for modern agriculture in the Philippines was laid down through these earlier efforts.

The operation of the ICA–NEC program and the contract between Cornell and Los Baños brought two tremendous forces into play to accelerate research in the college: (i) the sustained availability of ample funds for research, which permitted acquisition of needed facilities and adequate technical manpower, and (ii) the healthy intellectual cross-fertilization between two groups of people, American and Filipino. We certainly congratulate ourselves on the fact that Cornell could take over the contract with Los Baños, because it has afforded us close association with a great American agricultural institution, with its over-a-century head start over the Philippines in experiment-station work and with its American organizational know-how.

Research Benefits Farmers

As a result of these first years of collaboration, great strides have been made in agricultural research. The Filipino farmer is already beginning to reap the benefit of superior, higher-yielding varieties of rice of good eating quality, the foundation stock of which has been the result of the patient and persistent work of our plant breeders (Fig. 3). Five strains of double-hybrid corn, the first of their kind in the eastern tropics, have been outyielding the ordinary kinds, and in not a few cases the harvest reaches as much as 90 cavans per hectare (1 cavan equals 2.2 bushels).

Experiments have indicated that we overwater lowland rice fields, because it was found that 2.5 centimeters, or half or even a fourth as much as is now commonly used, accomplished the same re-

Fig. 3. New rice varieties are "born." Plant-breeding specialists at the college continually work to develop high-yielding varieties that do not fall over and become lodged or twisted together—a major problem in the Philippines. Such characteristics reduce yields and make harvesting difficult. D. L. Umali, head of the Division of Plant Breeding (left) and H. L. Everett, visiting professor from Cornell, inspect some of these new varieties.

Fig. 4. Sets of tanks are used in experiments at the college's Experiment Station to find out how much water is needed by growing rice plants. The findings being recorded here by A. B. Catambay, head of the Department of Agricultural Engineering (left), and Harold E. Gray, visiting professor from Cornell, have been used to plot the most profitable and economical use of water on farms.

sults (Fig. 4). Hence, a more rational management could make possible the expansion of irrigated areas two- to four-fold.

Effective insecticide treatment against the destructive rice borer and the rice bug has been found.

Eleven arabica coffee plants have been isolated as rust-resistant strains; these may well prove to be the beginning of the rehabilitation of this important money crop, which had been wiped out in Batangas in the 19th century by the rust. To accelerate distribution of rust-resistant arabica stock to farmers, further large-scale importation of these proven rust-resistant seeds was again made from India. With the cooperation of the Bureau of Plant Industry, these seeds are being planted in different stations in various parts of the country. The seedlings are sprayed with rust suspension to eliminate the small percentage of rust-susceptible plants. The survivors will then be distributed.

Artificial insemination to improve local livestock more effectively, speedily, and economically has been proved to be practical in this country. At present a central bull stud is being built on the campus, with the cooperation of the Bureau of Animal Industry, to serve livestock farmers in every province.

Research on soil and fertilizer needs of crops (Fig. 5), study of sociological and economic problems of the farm, utilization of agricultural products and by-products, and very many other projects have been undertaken. Attention to these different items is aimed at increasing production and putting more pesos in the farmers' pockets.

Fig. 5. One way to take research results to the farm is to conduct tests on a local farm for all to see. Here a college soil technician (left) is working with a farmer to find why leaves of the coconut tree turn yellow and why the tree stops bearing. With the use of different fertilizers, researchers could see improvements in the trees within three months, but the answers were still incomplete. Within three to five years they hope to have definite results, so that they can make recommendations to farmers.

Agencies and College Cooperate

One important aspect of our research program is that, for the first time in this country, there has come about a close and active cooperation between the college and the Department of Agriculture and Natural Resources, which is concerned with all phases of the agricultural programs of the Philippines. The result has been the further strengthening of the agricultural research program in this country, where, rather than being competitive, these entities now pool their resources.

Under this arrangement, the main responsibility of the college is basic research, while the corresponding bureaus of the Department of Agriculture and Natural Resources attend largely to development and extension. Because of varied conditions in different sections of the country, field stations of the department's bureaus have become available to college researchers for cooperative regional tests. For that matter, certain agricultural schools also participate as cooperators, to make it possible to cover many of the different climatic and soil conditions in the country. Hence, if a superior variety of rice or hybrid corn is recommended for any particular locality, the recommendation carries the assurance that it will be backed by a reasonably adequate study right in that vicinity.

Hand in hand with cooperation in research, cooperation with the Bureau of Agricultural Extension has been considered paramount. Taking useful information to rural people is the principal responsibility of this bureau in the Department of Agriculture and Natural Resources. Research is not of much value if it ends in the laboratory or experimental field. The results should reach farmers as quickly as possible so they can be put to use. In this difficult task, we have been leaning heavily on extension personnel.

Strengthen Agriculture First

Has too much emphasis been placed in this country on agricultural development at the expense of the industrial? The fact is obvious that a healthy economy demands that our agricultural pro-

gram be b[illegible]ed with a certain degree of industri[illegible]ation. Industrial research must, there[illegible], be properly attended to. Unfortuna[illegible] the tendency in too many countries, [illegible]luding those in our part of Asia, such [illegible] Thailand, Pakistan, India, Formosa, a[illegible] even our Philippines, has been to lau[illegible]ch a disproportionately ambitious pro[illegible]ram of industrialization and shove agriculture into the back seat. A swing to this extreme may well spell disaster, as was unfortunately the sad experience in Argentina, in Peron's time, when the economy of the country was nearly ruined through overindustrialization.

Before we can industrialize to any considerable extent, agriculture, which is the basis of our economy, must first be strengthened. Vigorous, sustained, and adequately supported research is necessary to solve the many important problems that still remain to be studied to make our farms give more bountiful yield. For a good many crops, superior seeds that could produce fourfold or more still await development. Better farm management has to be worked out to make operation more economical and more efficient; needs for fertilizer have to be more precisely determined; numerous pests, diseases, and weeds that exact a heavy toll on the harvest cry for more effective control.

As it is now, the average Philippine farmer, it is estimated, can raise only enough for himself and three other persons. Compare him, for instance, with the American farmer, who, after feeding himself, has enough left over for 20 other persons. As we raise the efficiency of our agricultural worker, more manpower could then be released to industries without harmfully affecting the farm, and the average per capita income would have sufficiently improved to take care of the market for the industrial products. These goals can hardly be attained if we slacken, rather than accelerate, the pace and intensity of agricultural research.

News of Science

IGY Oceanography

The deep currents in the South Atlantic Ocean, the ocean bottom, and the influence of a large river system on ocean bottom deposits will be investigated during the next 8 months by the research vessel *Atlantis*, which left the Woods Hole Oceanographic Institution last month on a cruise in the South Atlantic and Indian Oceans for the International Geophysical Year. Under the leadership of oceanographer Arthur R. Miller, the seven-man scientific party will make observations in the Brazil Current to fill in data obtained last year.

From a distance of about 1000 miles offshore from Buenos Aires, the *Atlantis* then will sail in the direction of the Rio de la Plata, obtaining long and short cores of ocean-bottom sediments for chemical analyses to determine the influence of a large estuary on ocean-bottom deposits. Bottom photographs will also be made. Upon arrival in Buenos Aires, Richard G. Leahy will leave the ship and transfer to an Argentine vessel to obtain sediment samples in the Rio de la Plata. He will travel upstream until sea water is no longer encountered.

The major task in the South Atlantic will be the making of observations of temperature, salinity, and dissolved oxygen from the surface down to the ocean bottom along latitude 32° S. Such observations will be made by stopping the ship every 80 miles, each "station" taking from four to five hours. In between stations the sea temperature will be measured hourly to a depth of 900 feet while the ship is underway with the aid of a bathythermograph.

The section between Buenos Aires and Cape Town will be the southernmost one to be finished in the British–U.S. IGY Atlantic Ocean program. Eight of the eleven east-west crossings have been made during the past year by the small (125-foot) research vessel *Crawford* of the Woods Hole Oceanographic Institution and the *R. R. S. Discovery II* of the (British) National Institute of Oceanography. By the end of 1958 the Atlantic Ocean water masses from Nova Scotia to Argentina on the west, and from Ireland to the Cape of Good Hope on the east, will have been examined. For the first time in history it will then be possible to provide a complete description of the three-dimensional distribution of the physical and chemical properties of the whole Atlantic Ocean. In the past satisfactory data existed only in rather limited areas, with the exception of the South Atlantic, where the German vessel *Meteor* made a survey in 1926–27.

During this IGY it has become possible for the first time to note whether any changes have taken place in the ocean during a 30-year period. Preliminary examination of the data acquired last year by the *Crawford* has shown but little change in temperatures and salinities but a significant loss in dissolved oxygen in deep water. A similar loss in oxygen has been found in the North Atlantic, compared with observations made nearly 30 years ago by the *Atlantis*. It is believed that neither in arctic nor in antarctic water has it been cold enough in recent years to form water of sufficient density to replace the very cold water now present in the deep ocean. In other words, the deep ocean water is getting "older" and is not being replaced by oxygen-rich waters from the surface.

Plankton tows and other observations. Biological observations will be made by Langley Wood and Robert Risebrough. These will include the making of plankton tows and chemical determinations of nutrients in the sea. Such observations will be especially important in the Indian Ocean, which rarely has been visited by oceanographic vessels.

Lamont-Woods Hole Indian Ocean Expedition. After arrival in Cape Town, South Africa, in the latter part of April, most of the members of the scientific party will fly back to Woods Hole and be replaced by a group of geophysicists under John W. Graham. The latter group will take the ship through the Indian Ocean and Red Sea, working together with the research vessel *Vema* of the Lamont Geological Observatory of Columbia University. The two ships will make echo-sounding profiles of the ocean bottom and, with the aid of explosives, determine the thickness of the sediment on the ocean bottom and the character of the bedrock below the ocean floor.

Seismic observations made in the Atlantic and Pacific Oceans in recent years have shown significant differences in the rock strata and in the thickness of the earth's crust between continents and ocean. Bottom photographs will also be made with the aid of a newly developed deep-sea camera that was successfully used in 1957 to obtain hundreds of exposures during each of several lowerings.

The two ships will cruise together over the location of a major crack in the earth's crust discovered by Lamont scientists. The expedition also expects to study uncharted submarine mountains. Heavy steel dredges can be lowered to obtain rock samples from the sides of such mountains.

This is the longest cruise the *Atlantis* has undertaken in her 28-year career. The vessel has made 240 cruises, the longest having been a 6-month investigation of the Mediterranean Sea in 1947–48.

Population Growth of United States and Canada

Both the United States and Canada scored record population gains in 1957. In the United States the increase exceeded 3 million for the second year in a row, raising the total population, including the Armed Forces overseas, to 172,830,000 at the end of the year. In the 7¾ years since the 1950 census, 21.7 million people have been added to the population, an increase of 1.7 percent annually. Canada has been experiencing a much higher rate of growth, the population having increased by 2.9 percent a year since the June 1951 census. At the close of 1957, Canada's population reached 16.9 million, an increase of about 556,000 during the year and of almost 2.9 million since June 1951.

Study Abroad

More than 75,000 international scholarships and fellowships for study in 83 countries and dependencies are listed in the 1957–58 edition of *Study Abroad*, a handbook published by the United Nations Educational, Scientific and Cultural Organization. The handbook includes such information as eligibility requirements, application procedures, amount of awards, and length of courses. It also lists 250 information centers in 50 countries which advise foreign students on living conditions, tuition fees, and enrollment procedures.

According to a 1955–56 UNESCO survey, reported in *Study Abroad,* of a total of 140,744 persons studying outside their countries during that period, 36,494 came to the United States, more than to any other country. France, with 16,877 foreign students, was second, followed by the U.S.S.R. with 12,300.

Study Abroad ($2.50) is sold by: UNESCO Publications Center, 801 Third Ave., New York 22, N.Y.; U.N. Bookshop; and Columbia University Press, 2960 Broadway, New York 27, N.Y.

Grants, Fellowships, and Awards

Biology. Applications are invited for a new $5000 scholarship in biology that has been established by the General Biological Supply House, Chicago, Ill. The award is open to an American citizen who is studying for the doctorate degree in botany, zoology, or biology. Applications should be submitted *before 24 March.* For information, write to the chairman of the award committee, Dr. Frank A. Brown, Jr., Department of Biological Sciences, Northwestern University, Evanston, Ill.

Chemistry. The Association of Official Agricultural Chemists has announced that nominations are now being accepted for the second annual Harvey W. Wiley Award for achievement in analytical methods. This $500 award goes to the scientist who has made an outstanding contribution to the development of methods of analysis for foods, drugs, cosmetics, feeds, fertilizers, and pesticides, or for use in general analytical chemistry. Nominations must be submitted *by 1 April.* Nominees need not be members of the association. Further information may be obtained from the secretary of the association, William Horwitz, Box 540, Benjamin Franklin Station, Washington 4, D.C.

Mental health. The Adolf Meyer awards committee of the Association for Improvement of Mental Health, Inc., is inviting nominations for the 1958 awards, which will be announced in May during Mental Health Week. These awards are given annually to individuals and/or organizations who have made meritorious contributions to the professional care and treatment of the mentally ill, both in and outside of hospitals. Nominations for this award should be sent *before 1 April* to Dr. Milton M. Berger, Chairman, Advisory Committee, A.I.M.H., 50 E. 72nd St., New York 21, N.Y.

Ornithology. The Frank M. Chapman Fund of the American Museum of Natural History was established to provide financial assistance to those conducting research in ornithology. The awards are usually made to younger scientists, in particular to graduate students, but there are no hard and fast restrictions. Applicants should bear in mind that the field stations operated by the American Museum are frequently available for ornithological as well as other types of scientific work. The Archbold Biological Station at Lake Placid, Fla., the Southwestern Biological Station in the Chiricahua Mountains in southeastern Arizona, and the Lerner Marine Station at Bimini, Bahamas, as well as the collections and laboratories of the museum itself, should be mentioned in this connection. Applications should be received *before 31 March.* Each applicant should state clearly the nature of the proposed research and provide an estimate of the financial requirements of the project. Letters of recommendation should be included. All correspondence should be directed to the Chairman, Chapman Memorial Fund Committee, Department of Birds, American Museum of Natural History, Central Park West at 79th St., New York 24, N.Y.

Human Resources in Science

"America's Human Resources to Meet the Scientific Challenge" was the theme of a national conference at Yale University 3–4 February sponsored jointly by the President's Committee on Scientists and Engineers and the William Benton Foundation. The conference brought together 100 representatives of American science, education, industry, labor, government, religious and minority groups, and the nation's public communications media. The conferees considered the competitive position of the United States in world science and technology.

Principal speakers were Allen W. Dulles, director of the Central Intelligence Agency, who described "The Soviet Challenge"; James R. Killian, Jr., special assistant to the President for science and technology, who discussed steps needed "Toward a New Level of Excellence"; and Alan T. Waterman, director of the National Science Foundation and Lee A. DuBridge, president of California Institute of Technology.

Insecticide Threat

The National Audubon Society has urgently recommended that the Department of Agriculture stop all insect control programs in which highly toxic chemicals are broadcast unless incontrovertible evidence becomes available that no serious damage to human and wildlife resources will result. The society has requested the Secretary of Agriculture to stop the proposed control program for the imported fire ant on some 20 million acres in nine southern states. The program is already underway. At the same time, the society warned the general public that all use of highly toxic modern insecticides, fungi-

cides, and so-called pesticides by governmental agencies, farmers, and other land owners, including gardeners, carries with it a much higher potential of harm to human beings and wildlife than is generally recognized.

Mental Health Panel

A six-member panel of non-Government experts will provide consultation to the National Institute of Mental Health on the mental health research program conducted in laboratories and other facilities at the National Institutes of Health, Bethesda, Md., and at field stations. Membership of the panel, known as the Board of Scientific Counselors of the National Institute of Mental Health, is apportioned selectively between clinical and fundamental science categories to maintain balanced perspective. It is expected that in addition to their review of the institute's scientific activities the new counselling body will provide the director of the institute with objective viewpoints and guide lines on the long-range perspective of intramural research.

Membership on the board is for a term of 4 years. However, for the purpose of establishing a rotation of tenure, the terms of the initial appointees, which commenced 1 July 1957, will expire at staggered intervals. The board members are Horace W. Magoun, John Benjamin, Stanley Cobb, Jordi Folch-Pi, Robert F. Bales, and Neal E. Miller.

Science Adviser's Responsibilities

The 3 February Department of State *Bulletin* comments as follows about the recent appointment of AAAS president Wallace R. Brode as science adviser, a long-vacant State Department post [*Science* **126**, 175 and 182 (24 Jan. 1958)]:

"Dr. Brode's appointment signals a fresh emphasis on a postwar Department of State function curtailed in 1955 in order that the program might be reviewed and plans made for the future. Reexamination during the past year indicated the growing importance of activities of scientists as a significant element in formulating foreign policy and in carrying on relations with other governments. The new work will therefore be oriented more closely than before to the objectives of the Department and the Foreign Service. Both the Science Adviser and the science attachés will be responsive to requirements of other government departments that carry on scientific activities abroad, since certain of these activities form parts of the pattern of our foreign relations. Dr. Brode will also keep in close touch with Dr. Killian.

"As counterparts overseas of the Science Adviser in Washington, certain science attachés will be appointed to advise and collaborate with political, economic, and other embassy officers on those foreign-relations questions in which scientific considerations play a part. They will also assist other Federal agencies and private groups in carrying out their programs of scientific cooperation abroad, such as those of the National Science Foundation, the International Cooperation Administration, the National Academy of Sciences, etc. Like other members of the Foreign Service, they will keep the Department currently informed of developments significant for international relations."

White House Dinner for Scientists

Recently the President gave a science-military dinner at the White House, the first such state dinner ever held. It was about three-tenths military. All the rest of the guest list, which totaled 49 couples, represented the scientific community from Boston to California, with the exception of the chairman of the Federal Reserve Board.

In general, the military men outranked the scientists in protocol. The highest-ranking scientist, James R. Killian, Jr., the President's new special assistant for science and technology, was placed tenth on the protocol list. The next scientist named was Alan T. Waterman, director of the National Science Foundation, who was nineteenth on the list and immediately under Lieutenant General James H. Doolittle, chairman of the National Advisory Committee for Aeronautics. There the official protocol ended, and the other guests were named alphabetically.

Four Nobel Prize winners were present: John F. Enders, medicine and biology, Harvard University; Edward M. Purcell, physics, Harvard University; Isidore K. Rabi, physics, Columbia University; and Glen T. Seaborg, chemistry, University of California.

Navy Roster of Scientists

The Office of Naval Research has prepared a roster listing all civilian scientists and engineers, GS-13 and above, employed by the Department of the Navy. Bureau chiefs, commanding officers, and technical directors of laboratories use the list to locate qualified individuals for consultation or for unique assignments. The list supplements the roster of scientific and technical manpower maintained by the National Science Foundation.

Special lists of scientists and engineers can be prepared easily from the Navy roster, which includes some 3000 names on I.B.M. cards that contain 24 items of information about each person. Forty-five items are included in the questionnaire completed by each scientist or engineer. Special runs of I.B.M. cards have been made to obtain an alphabetical listing of all persons included, an alphabetical listing by naval activity, scientific speciality in which most competent, and by profession.

British Association Sends Congratulations

The British Association for the Advancement of Science congratulated the United States on the launching of an earth satellite in the following message to the president of the U.S. National Academy of Sciences:

"The British Association for the Advancement of Science congratulates the scientists of the United States of America on the successful launching of an artificial satellite. In itself a brilliant achievement, the launching has put into orbit around the earth a new instrument for the scientific investigation of extra-terrestrial phenomena which will assuredly lead to the acquisition of knowledge of inestimable human significance."

Tests of Educational Progress

Late in 1957, the Educational Testing Service released a new series of achievement tests for schools and colleges called the Sequential Tests of Educational Progress (STEP). Designed for use in grades 4 through 14, the tests are measures of critical skills in reading, writing, listening, mathematics, science, and social studies.

The STEP series, developed over a 4-year period, began with four basic assumptions about teaching and testing, which were agreed upon by the test specialists at ETC and the hundreds of educators they consulted. These assumptions are (i) that the primary goal of all education is the development of the individual student, (ii) that education is a continuous and cumulative process, (iii) that the focus of education is upon development of critical skills and understandings, and (iv) that the success of education can best be measured in terms of the individual's ability to apply his school-learned skills in solving new problems.

Educators then worked with ETS to build tests that focus on the outcomes of instruction rather than on its content. The tests confront a student with new and realistic problem situations. To solve them, he must use and apply the skills and understandings he has learned in the classroom.

A notable feature of the new STEP series is the effort made to have the tests reflect continuity in educational growth and measurement. This continuity was achieved by building into the test content itself a continuity of educational development and by developing in each field a single score scale that is continuous from the lowest level of the test to the highest.

Continuity of content was built into the tests by having curriculum experts from all levels in a field (from the lower grades of elementary school through the first two years of college) work out the test questions together and at one time. In the field of science, for example, the educators who wrote the questions for all levels were housed in one dormitory for a 2-week period, spending part of each day working together as a single committee. Thus the skills, concepts, and ideas regarded as important enough to test at one level were also tested at all other levels.

Information about the Sequential Tests of Educational Progress may be obtained by writing to the Cooperative Test Division, Educational Testing Service, 20 Nassau St., Princeton, N.J.

New Journals

Cowa Bibliography, Current Publications in Old World Archaeology and *Cowa Survey, Current Work in Old World Archaeology,* No. 1, 1957. Lauriston Ward, Ed. Council for Old World Archaeology, 11 Divinity Ave., Cambridge 38, Mass. $4 per year.

Current Contents of Pharmaco-Medical Publications, vol. 1, No. 1, Jan. 7, 1958. Eugene Garfield Associates, 1523 Spring Garden St., Philadelphia 30. Weekly. Minimum service charge $1500 per year.

Molecular Physics, vol. 1, No. 1, Jan. 1958. H. C. Longuet-Higgins, Ed. Taylor and Francis, London. Quarterly. $13.50 per year. (In the United States and Canada order from Academic Press, New York 3)

The Physics of Fluids, vol. 1, No. 1, Jan.–Feb., 1958. Francois N. Frenkiel, Ed. American Institute of Physics, New York. Bimonthly. Members, $8; others, $10.

Prod. Political research: organization and design, vol. 1, No. 2, Nov. 1957. Alfred de Grazia, Karl Deutsch, and Richard Snyder, principal agents. Box 294, Princeton, N.J. Bimonthly. Academic, $2; Educational Institutions, $3; Commercial, $10.

Revista Latinoamericana de Anatomia Pathologica, vol. 1, No. 2, July–Dec., 1957. Sociedad Latinoamericana de Anatomia Patológica, Box 2543, Caracas, Venezuela. Half yearly. $3.

Atomic Energy Advisers

Senator Henry M. Jackson (D., Wash.) has appointed a special advisory panel to the Subcommittee on Military Applications of Atomic Energy, of which he is chairman. Jackson described the group as a "nuclear brain trust" and said it is the first standing advisory group ever employed by a Congressional committee in the weapons field. Members of the new panel are Harvey Brooks, Gordon Dean, Ivan A. Getting, Roswell L. Gilpatric, Gaylord P. Harnwell, John Harold Lampe, Kenneth Mansfield, Oskar Morgenstern, Roger Revelle, Edward Teller, John A. Wheeler, and Clyde Williams.

High School Science in Michigan

The University of Michigan has released a report on the science and mathematics curricula of the 668 Michigan high schools accredited by the university. Beginning algebra is offered by 94 percent of the schools, intermediate or advanced algebra by 64 percent, college algebra by 2 percent, plane geometry by 90 percent, solid geometry by 30 percent, and trigonometry by 30 percent. One school offers a course entitled "analytic geometry and calculus," and several others offer units of analytic geometry and calculus in courses described as "advanced mathematics." Biology is offered by 90 percent of the schools, chemistry by 95 percent, general science by 52 percent, and physics by 90 percent. About four-fifths of the state's high schools are accredited by the university.

News Briefs

Atomic sterilization emerged from the experimental stage last month when Ethicon, Inc., started full-scale commercial use of electron beam sterilization in its Somerville, N.J., plant. Ethicon, a division of Johnson and Johnson, manufactures catgut sutures.

* * *

The 70th anniversary of the birth of Nicolai Ivanovitch Vavilov on 26 November 1957 was marked by celebrations of the following Soviet scientific groups: the Society of Naturalists (Moscow), the Timiriazev Agricultural Academy (Moscow), the House of Scientists (Moscow), and the Botanical Society of the U.S.S.R. It is reported that these celebrations indicate the development of an increasingly liberal attitude toward genetics in the U.S.S.R.

* * *

The third program of CBS Television's *Conquest* series on science and scientists will be shown on 9 March from 5 to 6 P.M. The program, which is sponsored by the Monsanto Chemical Company and presented in cooperation with the AAAS and the National Academy of Sciences, will be devoted to Antarctica, heart surgery, and the insect world.

* * *

The United States satellite's more powerful radio, which operated on 108.3 megacycles, stopped after 11 days. The second, broadcasting at 108 megacycles, is expected to operate until April.

* * *

The Association for the Aid of Crippled Children, in the interest of reducing pregnancy wastage, is compiling a book "The Placenta and Fetal Membranes—A Survey." A portion of the book will be comprised of brief descriptions of research work in progress. The association would appreciate receiving information concerning any projects which may be germane. The name and address of the investigator and information about the nature of the investigation should be sent to Dr. Louis M. Hellman, in care of Association for the Aid of Crippled Children, 345 E. 46th St., New York 17, N.Y.

Scientists in the News

BERTRAND RUSSELL, British philosopher, mathematician, and writer, has received the 1957 Kalinga Prize for the popularization of science, offered annually by the United Nations Educational, Scientific and Cultural Organization. Kalinga is the name of a foundation which contributes to the economic development and the social and cultural progress of the Indian State of Orissa. The Kalinga Prize of £1000 is offered for the purpose of recognizing the work of leading interpreters of science and of strengthening links between India and scientists of all nations. The prize fund is a personal donation of B. Patnaik, a member of the Legislative Assembly of Orissa. He is a director of the foundation.

Nominations for the Kalinga Prize are received each year from various scientific groups directly interested in the popularization of science, and particularly from national associations for the advancement of science and national associations of science writers. In 1957 there were seven candidates presented by associations in France, the Federal Republic of Germany, Italy, United Kingdom, United States, and Venezuela.

The nominations were considered by an international jury composed of Marcel Florkin, biochemist, president of the Association Belge pour la Diffusion de la Science (Belgium), L. J. F. Brimble, editor of *Nature* (United Kingdom); and J. L. Jakubowski, member of the

Academy of Science (Poland). Bertrand Russell was nominated by the Venezuelan Association for the Advancement of Science.

SAMUEL S. WILKS, professor of mathematical statistics at Princeton University, has been named as the new chairman of the Mathematics Division of the National Academy of Sciences–National Research Council. He succeeds PAUL A. SMITH, professor of mathematics at Columbia University, who has served as division chairman since 1955.

GOTTFRIED S. FRAENKEL of the department of entomology, University of Illinois, will spend from February to September in Japan on sabbatical leave endeavoring to learn why silkworms must have mulberry to survive. He was invited to Japan by T. YOKOYAMA, director of the Sericultural Experiment Station there. He will work with TOSHIO ITO, who was at Illinois in 1955–57.

DONALD B. LINDSLEY, University of California psychologist and a specialist in the human nervous system, will be the William James lecturer on psychology at Harvard University for 1958–59. In addition to the ten James lectures, which are open to the public, Lindsley will offer a graduate seminar during the fall term. Lindsley is best known for his analysis of brain waves, for which he employs electroencephalography.

HUTTON D. SLADE, chief of microbiology at the Rheumatic Fever Research Institute, Chicago, has been named associate professor of microbiology at Northwestern University Medical School. Slade's research efforts have been concerned with the group A hemolytic streptococcus. This microorganism causes infections of the respiratory tract which may lead to rheumatic heart disease.

Scientific visitors to North America from Australia include the following:

C. F. BRUCE, Division of Metrology, Commonwealth Scientific and Industrial Research Organization, has just completed a tour of the United Kingdom and Europe. His itinerary provides for visits to Montreal; Ottawa; Chicago; Lafayette, Ind.; Pittsburgh, Pa.; Rochester, N.Y.; Boston; New York; Philadelphia; Washington (22–29 March); Los Angeles; and San Francisco, from which he departs on 3 April.

W. R. SOBEY, Animal Genetics Section, CSIRO, is visiting the United States to see work on viruses, with particular emphasis on changes of specificity and genetic characteristics. His itinerary provides for visits to the University of California; Iowa State College; Mount Sinai Medical Research Foundation, Chicago; Indiana University; Washington University, St. Louis; University of Missouri; Gatlinburg, Tennessee; Madison, Wis.; New York; and Boston. He will be leaving for the United Kingdom on 7 May.

STANFORD B. SPRACKLEN, codeveloper of an industrial gas chromatograph for continuous stream analysis and control, has been named associate director of research and engineering for the Process Instruments Division of Beckman Instruments, Inc., Fullerton, Calif. Spracklen was for 13 years supervisor of instrument research and development for Union Carbide Chemicals Co., South Charleston, W.Va.

WARNER L. WELLS, assistant professor of surgery at the University of North Carolina, is to receive the university's O. Max Gardner Award on 22 March for discovering, translating, and editing *Hiroshima Diary, The Journal of a Japanese Physician, August 6–September 30, 1945,* by Michihiko Hachiya. The award is given to the "member of the faculty of the Consolidated University of North Carolina who in the current scholastic year has made the greatest contribution to the welfare of the human race."

JAMES H. BYWATERS, professor of poultry husbandry at Virginia Polytechnic Institute, has been named director of research at the William H. Miner Agricultural Research Institute, Chazy, N.Y.

JOHN F. SANDFORT, professor of mechanical engineering at Iowa State College, has been named head of the mechanical engineering department at South Dakota State College, effective 1 March. He replaces LEE L. AMIDON, who has been head of the department since 1941. Amidon, who remains on the staff as professor, prefers a 9-month appointment to the 12-month requirement for engineering department heads.

BENJAMIN FRIEDMAN has been appointed professor and director of the department of ophthalmology at New York Medical College, Flower and Fifth Avenue Hospitals. He has been on the staff of the institution since 1946, serving first as instructor and later as associate professor.

The third annual Priestley Lectures will be given at Pennsylvania State University on successive days, 24 March through 28 March, by HAROLD H. STRAIN of the Chemistry Division, Argonne National Laboratory. The lectures are sponsored by Mu Chapter of Phi Lambda Upsilon, honorary chemical society, and Pennsylvania State University as a memorial to Joseph Priestley, who spent the latter part of his life at Northumberland, Pa. Strain's topic for this year's lecture series is "Chloroplast Pigments and Chromatographic Analysis." As in the past, the collected lectures will be published and sold by the Mu Chapter of Phi Lambda Upsilon to help defray expenses.

Recent Deaths

H. L. EULER, Birmingham, Ala.; 66; professor and head of the department of psychology at Athens College; former supervisor in the adult-education program of the New York City Board of Education; 6 Feb.

WILLIAM A. FITCH, Ringoes, N.J.; retired pharmaceutical chemist; 8 Feb.

LEWIS B. HILL, Towson, Md.; 63; professor of psychiatry at Johns Hopkins University and psychiatrist in chief of the Sheppard and Enoch Pratt Hospital; 5 Feb.

FRIEDRICH G. KAUTZ, New York, N.Y.; 69; director of radiology and roentgenology at Knickerbocker Hospital; author of many papers on the radiological diagnosis of diseases of the bones and joints; 5 Feb.

LEE A. KEANE, New Canaan, Conn.; 63; chemical engineer; retired vice president of the United States Industrial Chemical Company; 8 Feb.

STOCKTON KIMBALL, Buffalo, N.Y.; 55; dean of the University of Buffalo Medical School since 1946; 7 Feb.

PHILIP R. LEHRMAN, New York, N.Y.; 62; professor of neurology and psychiatry at New York University–Bellevue Medical Centre; 4 Feb.

ELLEN C. POTTER, Philadelphia, Pa.; 86; physician and former Pennsylvania Secretary of Welfare, the first woman in the country to hold such a position; 9 Feb.

EDWARD G. REINHARD, Washington, D.C.; 58; professor and head of the biology department at Catholic University of America; taught invertebrate zoology; specialist in parasitic crustacea and in the history of parasitology; 29 Jan.

THOMAS STEWART, Berkeley, Calif.; 67; professor emeritus of chemistry at the University of California; 6 Feb.

EDWARD H. STROMBERG, Evanston, Ill.; 63; retired director of development and research of Northwestern University; 6 Feb.

Erratum: the term *Seconal,* a trademark of Eli Lilly and Company for secobarbital sodium, was used as a generic term in the issue of 20 Dec. 1957 (vol. 126, p. 1120, column 2, line 48).

Reports

Secondary Reinforcement Established with Subcortical Stimulation

Olds and Milner have demonstrated that direct electrical stimulation of certain structures of the brain has a rewarding effect (*1*). Rats with chronic electrode implants in the limbic system were observed to maintain high rates of self-stimulation if given the opportunity to do so by pressing a lever. Subsequent research has confirmed and extended this finding. For example, Olds has shown that rats will learn to thread a maze for a brain stimulation reward (*2*) and will even accept a painful shock to the feet by crossing an electrified grid to obtain direct brain stimulation (*3*). Using operant conditioning techniques, Sidman *et al.* studied the effects of presenting the electrical brain stimulus under different reward schedules (*4*). The characteristic rates of responding that are known to result when conventional reinforcing agents (like food or water) are presented on particular reinforcement schedules (*5*) were also obtained with brain stimulation reinforcement schedules. These studies make it clear that direct stimulation of certain brain structures can serve as primary reinforcement for the modification or maintenance of behavior.

The study described in the present report was directed at the investigation of the brain stimulation reward with respect to another important property of primary reinforcing agents—the ability to impart (secondary) reinforcing powers to originally neutral stimuli, if these stimuli closely and regularly precede the occurrence of the primary reinforcer (*6*). The present finding that electrical stimulation of the brain can serve as primary reinforcement in establishing secondary reinforcing powers in neutral stimuli extends the generality of its action as a reinforcer and also provides some information about the process through which neutral stimuli take on secondary reinforcing functions.

A slight modification of the classical paradigm for the establishment of and test for secondary reinforcement was used. Eighteen rats with chronic bipolar electrode implants in or near the septum or anterior hypothalamus were trained in a small chamber containing two levers in one wall. Pressing of one of the levers produced a 1-sec tone of clearly audible, but not uncomfortable, intensity. Pressing of the other had no effect. A series of six daily, 1-hour sessions established the neutrality of the tone, as a very slight preference induced initially for the no-tone lever was maintained generally throughout the 6-day period (*7*).

On the seventh day, both levers were removed from the chamber, and 100 presentations of the tone, followed 0.5 sec after its onset by a 0.5-sec train of brain stimulation, were given. The time interval between pairings was varied; the mean duration was 1 minute. The brain stimulation, which was supplied from a pulse-pair generator recently described by Lilly *et al.* (*8*), had a frequency of 100 cy/sec and a pulse-pair duration of 0.1 msec. The current for all subjects was set at approximately 13 ma (positive peak current)—a value known to produce a good reinforcing effect in most positive locations. This procedure was repeated for three additional days, at the end of which time all animals had received a total of 400 pairings of tone and brain shock.

The levers were then placed again in the chamber, and for the next 3 days, 1-hour test sessions were conducted under conditions that duplicated those of the pre-pairings phase. The same lever that produced the 1-sec tone in the first phase also gave a tone when pressed in the test phase, and no brain shocks were given.

If pairing the tone with the brain shock in the second phase establishes the tone as a secondary reinforcer, then two important effects are expected in the test period: (i) a switch in lever preference: the tone-producing bar will be pressed more frequently than the no-tone bar, and (ii), the absolute rate of responding at the tone lever will increase over the pre-pairings level.

These predictions are based on the premise that the brain stimulation employed in the pairings phase was itself positively reinforcing. To determine the primary reinforcing value of this stimulation for each animal, a fourth phase was included in the procedure. Immediately after the last test day, one of the levers was removed, and a train of brain stimulation of the same intensity and duration as that used in the pairings procedure was given for each response at the remaining lever. No tones were given in this phase. The rate of self-stimulation (lever-pressing) at the end of a 1-hour session was taken as a gross index of the reinforcing value of the brain shock (*9*). On the basis of these self-stimulation rates, an unambiguous division of the animals into two groups could be made. Thirteen animals (brain shock positive group) gave rates of 9 responses per minute or higher, and five animals (brain shock neutral group) had rates of 0.2 response per minute or less. The second group was used as a control.

The data used in the analysis for a secondary reinforcement effect are summarized in Fig. 1. The total number of responses to each lever in the three sessions immediately before and the three sessions after the pairings phase were tallied for each animal and then averaged over the two groups. In the curves for the brain shock positive group, the two indications that secondary reinforcing properties were acquired by the tone are clearly evident. The crossing of these curves reflects the shift in preference to the tone-producing bar; the sharp positive slope of the tone-bar curve reflects the absolute increase, exceeding 200 percent, in response frequency at that bar following the pairings.

Statistical tests affirm these observa-

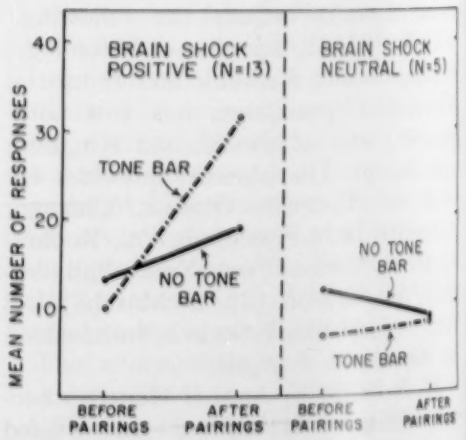

Fig. 1. Mean number of responses at the two bars for the three sessions before, and the three sessions after, the pairings phase for both groups.

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

tions. A *t*-test of the difference between the difference scores (responses to the tone bar minus responses to the no-tone bar) before and after the pairings gave $t = 4.07$ ($p = .001$, indicating a significant shift in lever preference. A *t*-test of the difference in response frequency at the tone bar before and after the pairings gave $t = 4.20$, $p = .001$.

In contrast, neither of these effects was obtained in the brain shock neutral group. The preference for the no-tone bar, although diminished, persisted after the pairings procedure, and the absolute increase in response frequency at the tone bar was negligible.

It is concluded that electrical stimulation of septal and hypothalamic structures can serve as primary reinforcement in establishing secondary reinforcing powers in neutral stimuli. This finding does not seem to be consistent with a theory of secondary reinforcement which assumes that a neutral stimulus must be established as a discriminative stimulus in order to function as a secondary reinforcer (*10*).

It is tempting to speculate that what may be involved here is a kind of neural conditioning, with the tone serving as the conditioned stimulus and the brain shock as the unconditioned stimulus. After the pairings, the tone has reward value because it gives rise to a conditioned neural discharge of a reinforcing nature (in, presumably, the same structure, stimulated electrically). Indeed, it should be possible, through the use of brain-wave recording techniques, to determine directly whether neural activity produced by direct stimulation of subcortical structures can in fact be conditioned to a sensory input.

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References and Notes

1. J. Olds and P. Milner, *J. Comp. and Physiol. Psychol.* 47, 419 (1954).
2. J. Olds, *ibid.* 49, 507 (1956).
3. J. Olds and J. C. Sinclair, *Am. Psychologist* 12, 464 (1957), abstract.
4. M. Sidman *et al.*, *Science* 122, 830 (1955).
5. C. B. Ferster and B. F. Skinner, *Schedules of Reinforcement* (Appleton-Century-Crofts, New York, 1957).
6. C. L. Hull, *Principles of Behavior* (Appleton-Century-Crofts, New York, 1943).
7. Prior to the first day of training, all animals were placed in the chamber for 1 hour, during which time neither lever produced any tone, in order that original lever preference might be determined. The tone was then associated with the nonpreferred lever.
8. J. C. Lilly *et al.*, *Science* 121, 468 (1955).
9. In the case of several animals that had zero or near-zero rates in the first hour, additional test sessions were conducted to make sure that the placements were not positive.
10. W. N. Schoenfeld, J. J. Antonitis, P. J. Bersh, *J. Exptl. Psychol.* 40, 40 (1950). The operations that imparted secondary reinforcing properties to the tone in the study described in this report (that is, the pairings with brain shock) did not provide, at the same time, the conditions favorable to its development as a discriminative stimulus. This is because the effective delivery of the brain shock reward requires no (operant) response on the part of the animal, in contrast to conventional reward situations which involve approaching and consummatory behavior. In a case such as this, it is hard to see how particular responses could have been selectively reinforced with brain shock in the presence of the tone to permit the formation of a discrimination. Furthermore, the brevity of the interval between tone and brain shock (0.5 second) would make the development of superstitious behavior in response to the tone unlikely. No evidence of such behavior was indicated by observation.

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22 August 1957

Effects of Brief Exposures to Cold on Performance and Food Intake

The relationship between food intake and temperature is usually studied, as is acclimatization in general, during prolonged exposure to one temperature. Under these conditions, rats typically show a configuration of changes that comprise the state called acclimatization. These include changes in heat production and food intake, endocrine structure and function, peripheral vascularization, and so on (*1*). In this paper, I report data (*2*) based on brief exposures to varied temperatures which appear to demonstrate acclimatization phenomena of very short latency.

Rats were exposed to a temperature of either 0°, 10°, or 20°C (±2°C) for 20 minutes per day. The apparatus used was a box 10 by 10 by 11 in. that contained a lever and a device for delivering a small pellet of food weighing about 0.04 g. The box was kept in an insulated enclosure connected to a refrigeration unit so that its internal temperature could be varied. The lever was connected in such a way that a food pellet was delivered once per minute, provided that the lever was pressed at the end of the period. This periodic reinforcement schedule was used in order to avert differences in food intake among the animals while they were in the apparatus. The animals were given access to food for only 1 hour following their exposure to the various temperatures.

Thirty male Sprague-Dawley rats, about 6 months old, were used as subjects. They were started on the study after 3 weeks of experience on the 1-minute periodic reinforcement schedule. Each animal was exposed to each temperature during each 3-day experimental period. There were eight of these periods, or 24 experimental days in all, for each rat. Three different sequences of exposure were used, with ten animals assigned to each sequence, and each group repeated its assigned sequence four times. These sequences were as follows: Group 1: 0°, 20°, 10°, 20°, 0°, 10°C; group 2: 10°, 0°, 20°, 10°, 20°, 0°C; group 3: 20°, 10°, 0° 0°, 10°, 20°C.

The performance criterion was the number of lever-presses made during each experimental session. The data on food intake are based on the amount of food eaten in the 1-hour period following the 20-minute exposure. This food was a commercial dog food (Red Chain) that had been crushed to powder form. Feeding cups with perforated inserts were used to prevent spilling.

Figure 1 shows the performance data for the first four periods (*3*). Each point in this figure is based on the performance of all 30 animals. During the first period, response frequency was greatest for the highest temperature and least for the lowest temperature. Then, because of increases in responses at the two lower temperatures, the frequency for all three temperatures became about the same. Since rats exposed to cold eat more food, one would expect them to respond more frequently at lower temperatures because of the correlation between length of food deprivation and rate of lever pressing (*4*).

Figure 2 reveals the amount eaten in

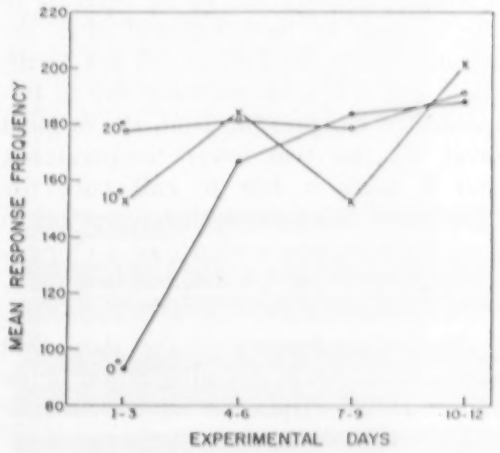

Fig. 1. Performance (lever-pressing) data at the three different temperature levels during the first four of the eight 3-day periods.

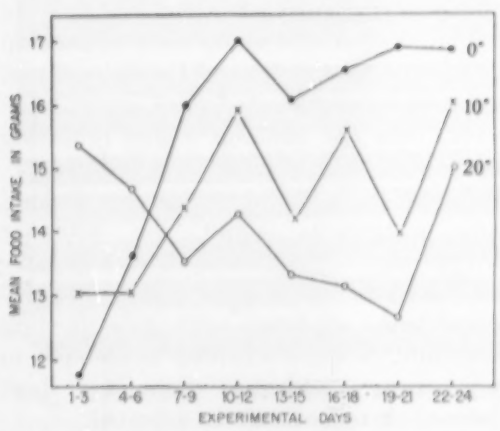

Fig. 2. Food intake during the hour that directly followed exposure to the three different temperatures to which the rats were subjected during the eight 3-day periods of the experiment.

the 1-hour period following exposure to the three temperatures during each of the eight 3-day periods. During the first period, the rankings are exactly the reverse of what would be expected on the basis of heat production and caloric need in the cold. By the third period, however, the rankings are in accord with this expectation. An analysis of variance performed on these data showed that differences among temperatures and periods attained the .001 level of significance.

A second study—this one of response to 20-minute exposures to temperatures of either −10° or 20°C for six consecutive days—showed, during an 18-day period (which allowed for two reversals), results similar to those obtained in the first experiment. Both food intake and frequency of response at the lower temperature tended to increase for about 3 days and then to level off.

One criterion of acclimatization is a change in behavior that is more adaptive in one particular situation than in another. In the present situation, acclimatization would be evinced by a greater response frequency at lower than at higher temperatures (provided that bar-pressing is not inefficient as a method of producing and conserving heat for a limited period) and by an increase in the amount of food ingested after exposure. While the former did not occur, there was still a considerable rise in frequency of bar-pressing from the original level for the two lower temperatures, and I think it fair to call both the changes in bar-pressing behavior and in food consumption evidence of acclimatization—or, at least, a form of acclimatization.

The other feature of the data that seems pertinent to acclimatization is the retention of adaptation in the face of constant shuffling of the exposure temperature. Perhaps most striking is the specificity that soon appears in food intake. This short-term adaptation of energy intake to energy output is one of the three types of energy regulation postulated by A. Mayer (*5*), who, in the rabbit, found this short-term regulation to be the most precise of the three types. It must be emphasized once more, however, that the findings I am reporting are based on very brief exposures.

These data do not warrant making any statements about the ultimate mechanism of regulation of food intake. It would seem, though, that day-to-day regulation, at least with this feeding schedule, is quite sensitive to changes in temperature and that there is a short latency of response to its effects.

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3. Only the first four periods are included in this graph because the animals were changed to a 3-minute periodic reinforcement schedule, beginning with the fifth period, and the data for the last four periods are therefore confounded with the response to the changed program.
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17 October 1957

Apparent Exception to the "All or None" Law in Cardiac Muscle

The "all or none" law as applied to muscle states that the strength of the contraction is independent of the strength of the stimulus. Recently my coworkers and I observed an apparent contradiction to this principle. We were repetitively stimulating, at threshold voltage, an excised cat papillary muscle in a saline (*1*) bath by means of mass platinum electrodes lying alongside the muscle. When the stimulus voltage was suddenly doubled, the contractions, after a few seconds' delay, became gradually more forceful until they were about 100 percent above the previous level (Fig. 1*A*). When the voltage was returned to the threshold value, the contractions, after some delay, returned to the base line. The phenomenon was repeatable, and all cat papillary muscles (18 in all) have shown this response in varying degrees. With a tenfold increase in stimulus voltage, the augmentation was much more pronounced.

These observations suggested that some fibers, quiescent at the lower voltages, were activated by the stronger stimulation—that is, that the papillary muscle was not a functional syncytium. The delay in the onset of the augmentation could be explained by assuming that some time was required before the recruited fibers reached maximum tension (treppe phenomenon). To test this suggestion the muscle was speared with a KCl-filled glass microelectrode having a maximum diameter at the tip of 0.5 μ (*2*). Resting and action potentials were recorded from 697 individual cells in 12 cat papillary muscles during electrical stimulation at threshold voltages (*3*). No cells were found that showed a resting potential but no action potential, such as might be expected to exist if the nonsyncytial hypothesis were correct. Accordingly, it was abandoned.

Results from eight isolated strips of cat atria suggested another hypothesis. In this tissue, under similar conditions, strong stimulation produced an initial depression, then a post high-voltage rise in the contraction strength (Fig. 1*B*). Since acetylcholine would be expected to depress the contractions and would be expected to be present in the atria, it seemed possible that the strong stimulation had caused the release of this autonomic mediator. Indeed, atropine consistently blocked the depression and unmasked the augmentation produced by strong stimulation (Fig. 1*C*). These observations were consistent with the view that, in the atrium, both acetylcholine and a potentiating substance were released by the high voltage. When the stronger stimulation was terminated, the release of both substances diminished (or ceased), but the rapid hydrolysis of the acetylcholine permitted the post-stimulation augmentation by the potentiating substance. The possibility that acetylcholine is responsible for both depression and augmentation cannot be overlooked. [Burn (*4*) cites several examples of the potentiation of contractions by low doses of acetylcholine.] If this were the case, however, one would expect that some augmentation would precede the depression, but this did not occur.

Since it seemed reasonably certain that acetylcholine was the depressing agent, it followed that epinephrine or norepinephrine might be the potentiating substance in both the atria and the papillary muscle. In addition to these considerations and the fact that these hormones are known to be present in heart muscle (*5*), there were other indications that implicated the epinephrines. For instance, spontaneous activity commonly

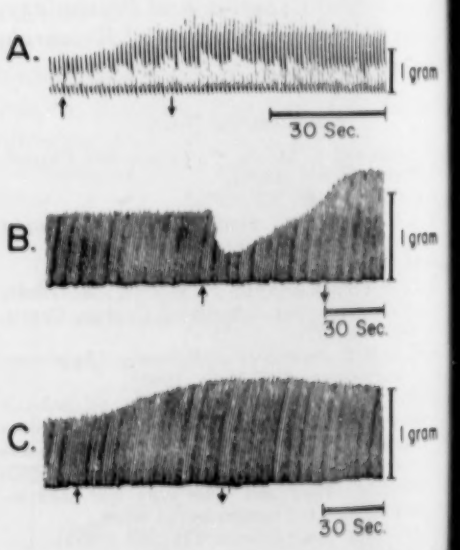

Fig. 1. *A*, Isometric contractions of driven papillary muscle of cat. At upright arrow, stimulus voltage was suddenly increased from 40 to 80 v; at inverted arrow, voltage was reduced to 40 v (threshold). *B*, Isometric contractions of left atrium of cat; arrows same as *A*. *C*, Same as *B*, 5 minutes after the addition of 10 μg of atropine to 8 ml bath.

occurred a few seconds after the strength of the stimulus was reduced to the threshold value. Incidentally, the spontaneity could usually be stopped by again increasing to high voltage. Also, the threshold for electrical stimulation fell during and shortly after a period of high-voltage stimulation. The similarity of the responses to strong stimulation and the effects of adding epinephrine or norepinephrine is striking. Finally, large amounts (150 $\mu g/cm^3$) of the sympatholytic drug dibenamine abolished or minimized the augmentation in both the atria and the papillary muscle.

It has been tentatively concluded that acetylcholine is the depressor substance and that one of the epinephrine compounds is the potentiating substance. The relative amount of each substance released will determine whether depression or potentiation will predominate. Thus, the lack of a significant depressor effect in the papillary muscle is explained by a relative absence of acetylcholine. In the atria, released acetylcholine overwhelms the concomitant release of the potentiating substance.

It is obvious that this phenomenon should be considered in interpreting the results of experiments which involve electrical stimulation of cardiac tissue. In pharmacological studies on isolated muscles, at least, it is quite possible that certain drugs may exert their effects by altering the threshold for the release of these substances. Further, if different areas of the heart contain different amounts of the two substances, as suggested here, uniformity of results with different tissues could hardly be expected.

More significance might be attached to these results if it could be demonstrated that these substances are released in the spontaneously beating heart strip or in one stimulated by point electrodes at threshold voltage. This seems a likely possibility in view of the fact that acetylcholine and the epinephrines are released in the spontaneously beating perfused heart (*4*). If these substances are released with each normal contraction, a number of previously described phenomena might be explained. For example, the treppe phenomenon and post-stimulation potentiation could well be explained on this basis (see *6*). Also, the opposite effect ("negative" treppe) seen in the rat ventricle could be due to a relative absence of the potentiating substance. Indeed, preliminary studies indicate a crude correlation between the magnitude of the high-voltage potentiation and the extent of the treppe phenomenon and of post-stimulation and extrasystolic potentiation (*7*).

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4 November 1957

Long-Term Recording from Single Neurons in Brain of Unrestrained Mammals

Much of our knowledge of the activity of single neurons in the central nervous system has been concerned with the study of phenomena of short time course —milliseconds to hours—and has involved the use of anesthetized animals, animals with brain lesions, or animals restrained by curarization. Some information is beginning to appear on the activity of single neurons in unanesthetized normal animals, but this is limited to activity of, at most, a few hours for the same neuron (*1*).

It has been found possible to record discharges of single neurons for periods of a week or more by implantation of several stainless-steel wires, 80 μ in diameter, with insulation exposed at the cross section of the tip. The animal in use is the California ground squirrel, *Citellus beecheyi*, which is being used in a study of brain mechanisms in hibernation.

The implantation technique is fully described elsewhere (*2*), and since it involves many details necessary for the particular measurements made in hibernating squirrels, only the details pertinent to this report are described here. The anesthetized squirrel was placed in a specially designed stereotaxic instrument, and holes were drilled and tapped in the skull for four 0-80 stainless-steel machine screws; smaller holes (approximately 340 μ in diameter) were drilled at desired sites for the 80-μ stainless-steel insulated wires. The single 80-μ wires were lowered into the brain through the latter holes with the aid of a manipulator or, for short distances, merely by hand. A dental cement was applied around the base of the electrode and allowed to run onto one of the screws; after the cement had hardened, the electrode holder was loosened and withdrawn. Ordinarily, four to six of these particular electrodes were implanted in the brain of each animal. About 2 mm of the free end of the 80-μ wire was carefully stripped of its insulation and a No. 28 gauge color-coded flexible lead was soldered to it. Several more layers of the dental cement were applied until the solder junction was firmly imbedded. The leads were all brought together, tied at intervals, and passed through a flexible plastic tube, which was then imbedded in cement at its base.

Connection to the unanesthetized, unrestrained squirrel was made by merely plugging in the appropriate leads; these ran out of the animal's cage, and handling of the animal was not involved. Conventional amplifying and recording equipment was used, and the potentials at the tip of the electrode were referred to one of the screws on the skull, which was grounded. With the method of connection used it has been possible to study unit patterns during intervals when the squirrel was falling asleep, waking, and in the alert state.

Figure 1 illustrates the discharge of a unit with a predictable pattern when the squirrel is alert and, in this case, curled up in its nest. The room was dark and the squirrel had been made immune to camera noises by puncturing of both eardrums and plugging of the external meati with cotton at the time of electrode implantation. Three long impulse trains of consecutively shorter duration are shown, with relative silence between trains. Each train is further characterized by a high-frequency outburst close to the start of the train. The slow waves have been filtered out; they are normally

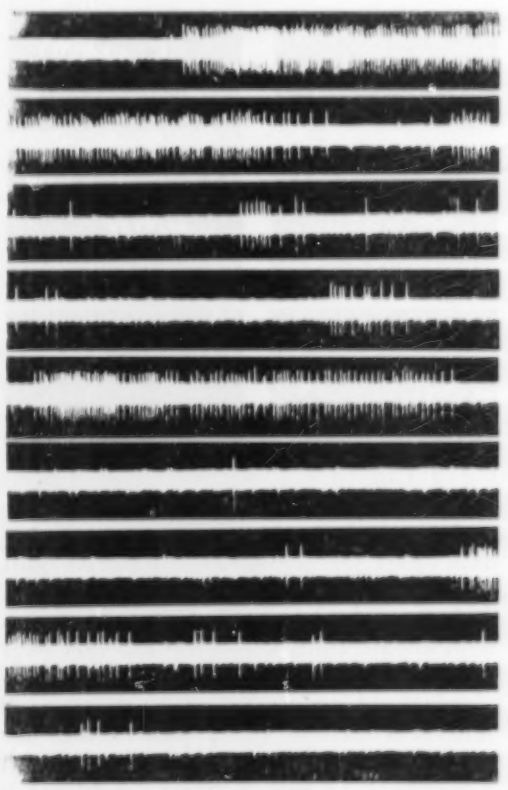

Fig. 1. Pattern of a unit in the mesencephalic reticular formation of an alert, deafened squirrel, resting in the dark, recorded on the eighth day after implantation of the electrode. Time for each strip is 4.6 sec; spikes average 60 μv; time constant, 2 msec.

large enough in amplitude to mask the spikes.

The single fast sweeps shown in Fig. 2 are from a different squirrel and illustrate some of the spike wave forms encountered at a recording site and their persistence some 4 days later. The constant wave form and relatively constant amplitude of the matching pairs support the thesis that these are the action potentials of single and identical neurons.

Studies have so far been limited to the cells of the mesencephalic reticular formation, which are among the largest in the brain; the technique in its present form may not be applicable to all parts of the nervous system.

An observation of interest is the presence of some cells in this region which are predominantly active during sleep, with only short low-frequency bursts or no activity during the alert state. Activity evoked by visual and tactile stimuli can be recorded from this region.

The difficulty of determining the significance of a unit discharge evoked by some peripheral stimulus is obvious. For example, a single flash of light can be observed to evoke the discharge of some relatively silent units in the mesencephalic reticular formation and also to further desynchronize the cortex, alert the olfactory bulb, speed up the heart, and increase muscle tone. It would be difficult to categorize these units as being related to any of these components of the animal's total behavior because of the many variables of similar time course which are changing and are not being recorded. It is quite possible that the unit evoked may not be even indirectly connected with any of these components.

In conclusion, it is felt that techniques which allow the study of the behavior of neurons over a period of days are of potential value in understanding long-term phenomena in the central nervous system, including learning, memory, and recall; these techniques are now available (*6*).

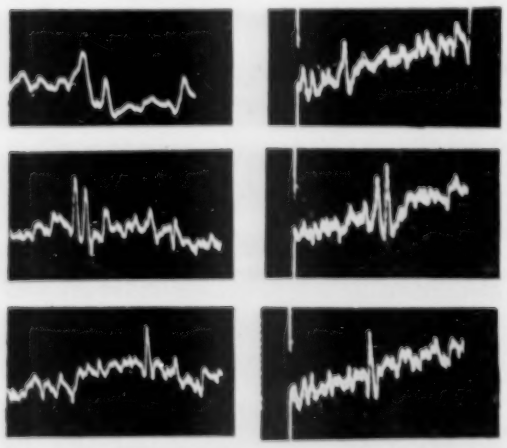

Fig. 2. Comparison of wave forms of similar spikes from one locus in the mesencephalic reticular formation, recorded 4 days apart (recordings in column at right were made 4 days later than those at left). This locus has three distinct spikes, each with a wave form which did not vary over hundreds of observations; a negative diphasic with a preliminary exponential inflection on the rising phase (top, see *3, 4, 5*); a larger negative diphasic with a tendency to fire in pairs (middle); a triphasic spike (lower). The spikes seem to fire independently of each other. Negativity, up; time of each sweep is 8 msec except for upper left, which is 4 msec; amplification of recordings in column at right is 1.3 times that on left; time constant (left), 200 msec, (right), 2 msec.

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23 December 1957

A Study of Grain Contacts in Granitic Rocks

In order to determine whether a concurrently crystallizing or previously crystallized mineral grain in a granitic rock affects the development of neighboring crystals, a study has been made of the contact relationships of minerals in thin sections of various granites. The study is based on the presumption that, if the different minerals in granites are randomly and uniformly distributed, then the percentage of contact area of a mineral *A* that is in contact with any other mineral *B* should be proportional to the modal percentage of mineral *B* in the rock. In such cases of proportionality, it may be presumed that minerals did not affect the development of neighboring grains.

For all possible pairs of minerals in the granites studied, the following ratio was measured: percentage of total contact length of all grains of mineral *A* occupied by mineral *B*/modal percentage of mineral *B*. The modal percentages were measured by point counting, and the various contacts were measured by retracing the traverses used in point counting and counting the number of times each possible contact (for example, a quartz-plagioclase contact) was crossed. Grain contacts along which albite, chlorite, or other presumably secondary minerals were concentrated were counted as contacts between the two primary minerals on either side of the secondary material.

A total of 31 granitic, quartz monzonitic, and granodioritic rocks were studied. Samples were obtained from a wide range of localities; they included Southern California batholiths; intrusions in the Front Range (Colorado), intrusions in the Sierra Nevadas (California), the Idaho and Boulder batholiths, and the White Mountain, New Hampshire, and Oliverian series of New England. The average composition of these rocks is 32.3 percent quartz; 27.7 percent potassium feldspar; 32.6 percent plagioclase; 6.6 percent biotite; minor hornblende (in a few samples); and rare magnetite, zircon, sphene, apatite, and muscovite.

The results are shown in Table 1. The numbers in this table are the geometric means from all samples studied of the ratio: percentage of contact length of mineral *A* in contact with mineral *B*/modal percentage of mineral *B*. In a few samples either potassium feldspar, plagioclase, or biotite was absent, but all means represent at least 28 samples.

As shown by Table 1, many of the ratios are close to one. Statistical *t* tests of the logarithms of the ratios from each sample confirm, at the 99-percent confidence level, that the potassium feldspar-potassium feldspar and plagioclase-plagioclase ratios are less than one. None of the other ratios involving quartz, potassium feldspar, or plagioclase are demonstrably different from one. The percentage of contacts of all minerals with biotite (as the mineral *B* in Table 1) are greater than one, probably because the irregular shape of the biotite causes it to have a large surface area for its volume.

Presumably ratios close to one in Table 1 signify that the minerals involved have had little or no effect on one another's crystallization. In the case of potassium feldspar, a low ratio with other potassium feldspar grains probably indicates that growth of one feldspar crystal prevents nucleation of a similar crystal in the neighborhood. This same explanation might also apply to the low plagioclase-plagioclase ratio, but it is

Table 1. Geometric means of the ratio: percentage of contact length of mineral *A* in contact with mineral *B*/modal percentage of mineral *B*.

Mineral *A*	Mineral *B*			
	Quartz	Potassium feldspar	Plagioclase	Biotite
Quartz	0.84	0.99	0.95	1.60
Potassium feldspar	1.21	0.45	1.15	1.29
Plagioclase	1.04	1.06	0.72	1.63
Biotite	1.09	0.66	0.81	1.20

also possible that early crystallization of plagioclase grains causes them to be isolated from each other by later forming minerals such as quartz and potassium feldspar. Quartz, however, does not seem to affect the development of neighboring grains, and it also appears that no mineral affects the development of other mineral species (*1*).

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Note

1. This research was financed by the Harry Carothers Wiess fund of the department of geology of Rice Institute. We thank John M. Whitfield for helping to assemble the collection studied.

13 November 1957

On the Presence of 3-Hydroxytyramine in Brain

The compound 3-hydroxytyramine has attracted interest as a probable intermediate in the biosynthesis of noradrenaline and adrenaline and also as a possible neurohumoral agent. It has been shown to occur in the urine (*1*), in the adrenals (*2, 3*), and in the heart (*2*) of sheep and in the splenic nerve of the ox (*4*). The study of this compound has been hampered by lack of sensitive and specific assay methods. Apart from bioassay techniques, only the fluorimetric ethylenediamine condensation method of Weil-Malherbe and Bone (*5*) appears to be sufficiently sensitive for biological purposes. However, with this method the fluorescence spectra obtained from 3-hydroxytyramine and adrenaline are almost identical (*6*). In the fluorimetric method of Euler and Floding (*7*), the fluorescence obtained from 3-hydroxytyramine is very weak and amounts to only a few percent of that obtained from noradrenaline or adrenaline.

Recently we observed, however, that if the *p*H of samples prepared essentially according to this method was adjusted to about 5 by means of acetic acid, a fairly strong fluorescence developed. Furthermore, the activation and fluorescence peaks (345 and 410 mμ, respectively, as read in an Aminco-Bowman spectrophotofluorimeter) were at much shorter wavelengths than those obtained from noradrenaline and adrenaline, so that these compounds did not interfere, even if they were present in comparably large amounts.

Using this technique in combination with ion-exchange chromatography (Dowex 50), we have started to investigate the 3-hydroxytyramine content of various tissues. We have thus found that 3-hydroxytyramine is present in rabbit brain in an amount of about 0.4 μg/g, which is roughly equal to the amount of noradrenaline in this tissue. This may indicate that the function of 3-hydroxytyramine is not merely that of a precursor. The following criteria argue for the identity of the apparent 3-hydroxytyramine in brain with authentic 3-hydroxytyramine: (i) identical activation and fluorescence peaks, (ii) similar behavior on an ion-exchange column, and (iii) identical R_f values on paper chromatography.

Like noradrenaline (*8*), 3-hydroxytyramine is made to disappear almost completely from brain by intravenous injection of reserpine (5 mg/kg). On the other hand, the injection of the precursor 3,4-dihydroxyphenylalanine (150 mg of the DL form per kilogram, intravenously) caused a very marked increase in the 3-hydroxytyramine content of the brain (to about 2 μg/g in less than 1 hour). This was accompanied by central excitation (*9*). Both these phenomena were markedly enhanced by pretreatment with iproniazid (Marsilid). Simultaneous changes in the noradrenaline level of the brain were much less pronounced if present at all (*10*).

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4 November 1957

Upper Atmosphere Densities from Minitrack Observations on Sputnik I

The analysis of Minitrack (*1*) data on the first U.S.S.R. satellite, 1957 Alpha 2 (*2*) provides information on the density of the atmosphere (*3*) above the perigee altitude of 232 km. We find that the observed rate of change of period for Alpha 2 may be explained by a model atmosphere which is in agreement with recently obtained data on air density and temperature at altitudes (*4, 5*) up to ~200 km and constitutes a reasonable extrapolation of these measurements to higher altitudes. With allowance for the estimated probable errors in the density at 200 km and for the uncertainty in the orbit elements and ballistic drag parameter of Alpha 2, the data still yield a relatively unambiguous determination of density up to 400 km.

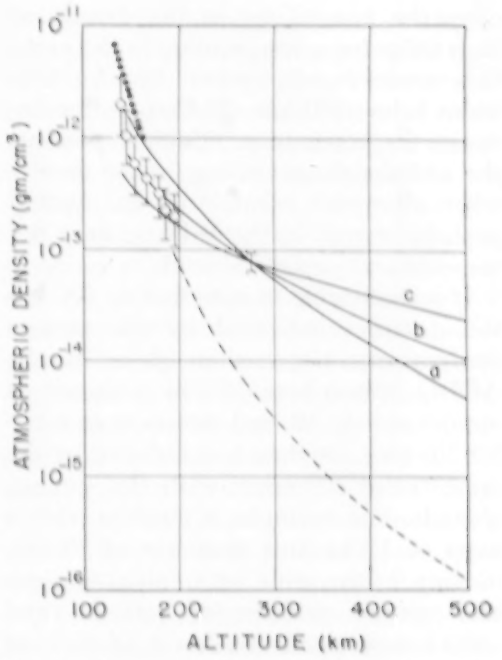

Fig. 1. Curves *a*, *b*, and *c* represent density distributions adjusted for simultaneous agreement with the rocket measurements and the α2 data. The dashed curve is the ARDC model atmosphere.

The determination of the density from the rate of change of the orbital period depends on the values of the ballistic drag parameter and the orbit constants of Alpha 2. The present calculations are based on a ballistic drag parameter of 89 ± 11 kg/m², derived from U.S.S.R. announcements of mass and area (*6*). The relevant orbit elements were deduced from Minitrack observations between 14 and 25 October, and their average values for that interval are as follows: perigee altitude = 232 ± 5 km; eccentricity = 0.047 ± 0.004; latitude of perigee = $39° \pm 6°$; equatorial inclination = $64.5° \pm 0.3°$; rate of change of period = 0.045 ± 0.003 min/day.

Our results are shown in Fig. 1. The solid lines represent three model atmospheres (*a*, *b*, and *c*) which agree with the rate of change of period of Alpha 2 and also fall within the limits of probable error in the rocket measurements of density up to 185 km. The data of Horowitz and LaGow (*4*) are indicated by circles, and the data of Byram, Chubb, and Friedman (*5*) by a dotted line. The dashed curve is the atmosphere proposed by Mizner and Ripley (*7*). The spread in the solid curves above 275 km indi-

cates the uncertainty in the density at high altitudes corresponding to the probable errors in the rocket data for altitudes below 200 km. The separation between the brackets at 275 km represents the additional uncertainty in the density when allowance is made for the quoted probable errors in the ballistic drag parameter and perigee altitude.

It is interesting to note that at 400 km the densities indicated by the present analysis are larger than those of the ARDC atmosphere (*6*) by a factor of approximately 40, and estimates of satellite lifetime are therefore reduced by the same factor for orbits with this perigee altitude. For example, a satellite with a mass of 10 kg and diameter of 50 cm, moving in an orbit with initial perigee and apogee altitudes of 400 km and 1000 km, respectively, has a lifetime of ~4 years in the ARDC atmosphere, versus 38 days in the present model (*b*).

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3. We are indebted to Mr. H. E. LaGow and Drs. H. Friedman, H. E. Newell, J. A. O'Keefe, and F. C. Johnson for valuable discussions on the properties of the upper atmosphere. We are also grateful to Mr. W. F. Cahill of the National Bureau of Standards for the preparation of the machine program for integration of the equations of motion, and to Mr. J. H. Wegstein for his collaboration in writing the earlier forms of that program.
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23 January 1958

Localization of Stretch Reflexes by Recurrent Inhibition

Feedback discrimination between active cells, and hence between their functional fields, appears to be a general property of nervous systems. When a cell, or group of cells, is activated, neighboring cells are frequently inhibited, and contrast between active and inactive zones is thereby enhanced. Such interaction has been described in the eye of *Limulus* (*1*), the cat's cochlea (*2*) and retina (*3*), the cat's trapezoid body (*4*), and the afferent path to the cat's somatosensory cortex (*5*). It is the purpose of this report to show that the antidromic inhibition which results from spinal motoneuron activity (*6*) represents a similar discriminatory mechanism; it creates a negative feedback that is instrumental to the localization of stretch reflexes and thus aids in the control of fine movement.

Antidromic activation of motor nuclei inhibits monosynaptic reflexes of neighboring nuclei (*6*). During the period of inhibition a repetitive internuncial discharge occurs (*7*), but lack of anatomical evidence dissuaded Renshaw (*7*) from linking the two phenomena causally. As the time course of motoneuron aftercurrents is very similar to that of the inhibition, current between neighboring cells might be responsible for the inhibition (*8*).

Recent work in which microelectrodes were utilized has provided strong evidence that the inhibition is mediated through the interneurons described by Renshaw, as a result of their having been activated cholinergically by recurrent motor axon collaterals (*9*). To strengthen the chain of evidence, a comparison has been made between the actions of an anticholinergic drug on (i) the inhibition of neighboring motoneurons, (ii) the electrical signs of activity in Renshaw cells, and (iii) the antidromic electrotonus of motoneurons reflecting current between them, as recorded on ventral roots.

All preparations were immobilized by intravenous injections of Flaxedil. Figure 1 shows that an intravenous injection of 0.5 mg of dihydro-β-erythroidine (DHE) (*10*) per kilogram reduces in magnitude the inhibition exerted by an antidromic volley in one fraction of the first sacral ventral root upon a monosynaptic reflex elicted by stimulation of the corresponding dorsal root and recorded in the remainder of the ventral root. Coincidentally (Fig. 2*B*), DHE shortens the duration of Renshaw cell discharge, as has been previously described (*9*). The small change in ventral root electrotonus (Fig. 2*A*) does not exceed changes seen between controls recorded at various times during the experiment. It is evident that DHE differentiates between antidromic inhibition and Renshaw cell discharge, on the one hand, and ventral root electrotonus on the other.

Since the inhibitory system is acti-

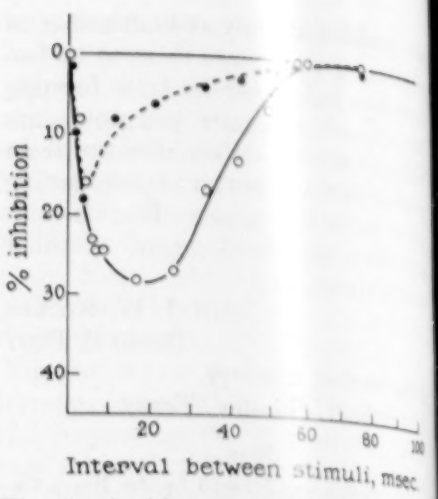

Fig. 1. Antidromic inhibitory curve obtained in a decerebrate preparation. For procedure, see text. Circles show inhibition before, dots after, intravenous injection of DHE. Each point was determined from 20 superimposed reflex responses.

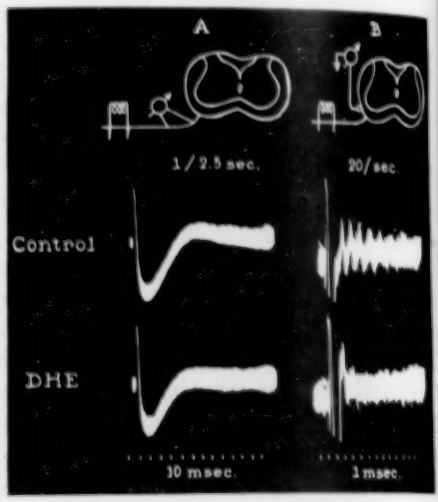

Fig. 2. Same experiment as illustrated in Fig. 1; (A) ventral root electrotonus, (B) Renshaw cell discharge, before and after injection of DHE. Diagrams show experimental arrangements.

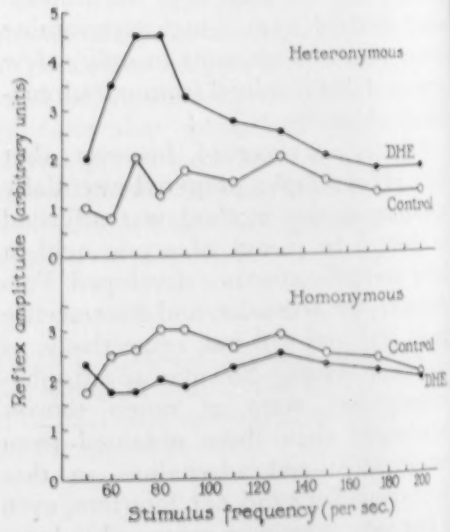

Fig. 3. Decerebrate preparation. For procedure see text. Graph shows, in arbitrary units, the effect of an intravenous injection of DHE on homonymous and heteronymous responses. Each point represents the average size of reflexes superimposed during a 1-second exposure.

vated by orthodromic as well as by antidromic impulses (*7, 11*), it may be well to abandon the term *antidromic* inhibition; *recurrent* inhibition is offered as a functionally more meaningful name. Because the system generally inhibits neighboring motoneurons, it has been assigned a nonspecific anticonvulsant function (*9*). In the normal animal, however, recurrent inhibition may play an important coordinating role. Monosynaptic reflexes, that represent stretch reflexes, ordinarily are confined to the path of afferent origin (homonymous reflexes). However, if the motoneurons of synergists are sufficiently excited, they may also be discharged (heteronymous reflexes). If the inhibitory system normally is a factor in restricting the field of stretch reflex action, then a reduction in the inhibition, as by the action of DHE, should result in an increase in heteronymous reflex transmission. To test this supposition, monosynaptic reflex discharges were elicited, before and after injection of DHE, by repetitive stimulation at frequencies of 50 to 200 per second. These frequencies were chosen because high-frequency stimulation is a convenient means for securing heteronymous reflex discharge (*12*) and because each response of the series will normally fall into the period of inhibition caused by its predecessor. Figure 3, taken from an experiment that is representative of many carried out with various flexor or extensor nuclei in spinal or decerebrate cats, shows a plot of the amplitudes of homonymous and heteronymous reflexes elicited in, and recorded from, the peripherally cut lateral and medial branches of the gastrocnemius nerves in a decerebrate cat. Administration of 1 mg of DHE per kilogram increased heteronymous, but not homonymous, reflexes. This discrimination requires no special distribution of Renshaw cells but, instead, follows from the fact that heteronymous reflexes usually are smaller than homonymous ones; an equal amount of inhibition exerted on both types would depress the smaller ones more. This discrimination varies from one experimental situation to another. In some experiments injection of DHE increased not only heteronymous reflexes but also homonymous ones. In several tests it was possible to evoke heteronymous reflexes after injection of DHE when they had been absent before.

It is concluded from the evidence described above that the recurrent inhibitory system tends to confine stretch reflexes to their paths of afferent origin.

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15 October 1957

Occurrence of Unequal Amounts of Free Methionine in Male and Female Drosophila melanogaster

An investigation by means of two-dimensional paper chromatography (*1*) of the free amino acids occurring in *Drosophila melanogaster* has revealed that wild-type females contain twice the amount of free methionine found in males. In previous chromatographic studies of the free amino acids of *Drosophila* (*2–5*), only one qualitative difference in the sexes has been reported—the occurrence exclusively in males of an unidentified substance presumed to be a peptide (*3*). Quantitative differences among amino acids have been cited but not documented (*4*). In the study discussed in this report, the difference in methionine content was confirmed by microbiological assay. In addition, the identification of this substance was made, and proof of its homogeneity was established, by isolation and chromatographic study of a dinitrophenyl derivative.

In the original chromatographic studies, whole flies were extracted with ethanol and the extracts were evaporated to dryness and redissolved in saturated picric acid to yield a protein-free solution. Chromatograms were developed, phenol-ammonia-water being used in the first direction, and lutidine-water in the second direction. Prior to development, the spotted samples were treated with ammonium molybdate and hydrogen peroxide.

This procedure converts essentially all the methionine in the extract to methionine sulfone, in which form it migrates as a distinct spot well separated from valine and alanine. The presence of Ninhydrin-reactive material at this position, as a result of the oxidation procedure, associated with a corresponding decline in amount of material at the position normally occupied by methionine, greatly facilitated the identification of the latter substance. In five different wild-type stocks, visual examination of chromatograms indicated the occurrence of twice as much methionine sulfone (and therefore of methionine) in females as in males.

To make sure that the larger amount of material at the methionine sulfone position in chromatograms of extracts of females was attributable solely to the presence of a higher level of this substance, the material was isolated and identified. Two-dimensional chromatograms of extracts of females were prepared in the usual way but were heated without spraying with Ninhydrin. The amino acids could then be seen as fluorescent spots when viewed under ultraviolet light.

The material in the methionine sulfone position was cut out and eluted with water, and a dinitrophenyl derivative was prepared. Chromatography of the reaction product in four solvents revealed the existence of a single substance whose R_f corresponded in each case with that of authentic dinitrophenyl methionine sulfone. This showed that the isolated material was methionine sulfone, and that the larger amount of material observed at the methionine sulfone position in chromatograms of extracts of females must be due entirely to the presence of a larger amount of this substance. It should be clearly recognized that the material present in the original extracts of flies is free methionine.

A bacterial assay was made in an effort to secure independent evidence that levels of free methionine differ with sex. For this purpose, tungstic acid filtrates of frozen flies were prepared by adaptation of methods previously described (*6*). The extracts were assayed in accordance with standard microbiological procedures (*7*) in which *Leuconostoc mesenteroides* P-60 and a completely synthetic methionine-free medium (*8*) were used. The amounts of free methionine found in extracts of wild-type male and female flies are shown in Table 1. Two experiments were per-

Table 1. Free methionine content of protein-free extracts of *Drosophila melanogaster*.

Expt. No.	Batch	Male (μg/g*)	Female (μg/g*)
1	1	200	475
1	2	190	420
1	3	360	430
Av.		250	442
2	1	300	585
2	2	305	610
Av.		303	598

* Wet weight.

formed, in each of which 2- to 3-day-old flies were collected as separate batches representing successive hatchings from a set of culture bottles. In both experiments extracts of females were found to contain twice the amount of methionine detected in extracts of males. With one exception the amounts found in the separate batches of a single experiment were relatively constant for each sex. However, the amounts of methionine found in the second experiment were higher in both sexes. The amounts of free methionine found are among the highest so far reported to have been found in an animal tissue (*9*). Separate studies have eliminated the possibility that the difference in males and females is attributable to the contents of the gut. The possibility that males and females have a differential ability to metabolize methionine is now under investigation.

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Elution of 3,4-Benzpyrene and Related Hydrocarbons from Soots by Plasma Proteins

The carcinogenic polycyclic aromatic hydrocarbon, 3,4-benzpyrene, has been identified as a constituent of soot. Its action in inducing skin cancers has been explained on the basis of the lipid solvent action of sebaceous secretions in eluting 3,4-benzpyrene from soot particles. Renewed interest in the carcinogenic properties of soot has followed the epidemiologic observation that the risk of development of lung cancer is greater among urban residents than among rural residents. Any description of the role soot may possess in the pathogenesis of human lung cancer must include an explanation for its biological activity in the lung.

In an earlier study we demonstrated that the carcinogenic hydrocarbon, 3,4-benzpyrene, which is routinely demonstrably adsorbed on soot, is absent in soot-laden human lungs (*1*). The morphologic demonstration of the intracellular entry of soot particles of appropriate size made it advisable to determine the effect of cellular and plasma proteins on the elution of benzpyrene from soot.

Soots of two representative sizes were studied in vitro for quantitative hydrocarbon determinations. One soot, of an average particle size of 80 mμ, was freed of essentially all polycyclic aromatic hydrocarbons by appropriate extraction methods and enriched by the adsorption of 3,4-benzpyrene onto the particles in a ratio of 1 μg of 3,4-benzpyrene to 1 mg of soot. The second soot was a commercial carbon black with an average particle size of 500 mμ. In their natural state these large particles contain a number of adsorbed polycyclic hydrocarbons.

The soots of the two sizes were handled in essentially the same manner. Ten-milligram samples of the enriched soot and 50- and 100-mg samples of the large-sized soot were placed in contact with an aqueous test medium consisting of 25 or 50 ml of sterile human plasma and were incubated at 37°C. The solutions were shaken constantly for 90 minutes in the 1.5- and 16-hour experiments and for 5-minute intervals to a total of 60 minutes of shaking in the remaining experiments. Incubation periods varied from 3 hours to 8 days. After exposure of the soot to the test medium, centrifugation or filtration was used to separate the soot from plasma. Three or four extractions with hot acetone were necessary for the removal of the adsorbed hydrocarbons from the soot.

Table 1. Percentage recovery of polycyclic aromatic hydrocarbons from 500 mμ soot and plasma after incubation of various durations; *t* trace; *p*, present.

Compound (μg/100 mg of soot)	1.5 hours			16 hours			96 hours			8 days			
	Soot	Plasma	Total	Soot	Plasma	Total	Soot	Plasma	Total	Soot	Plasma	Total	Saline soot
Pyrene (8.4)	9	81	90	34	61	95	9	50	59	6	61	67	100
Fluoranthene (1.0)	*t*	≈ 100		*p*	*p*		0	*p*		*p*	*p*		100
Compound X (2.8)	0	100	100	*t*	93		0	*p*		0	39	39	100
1,2-Benzpyrene (2.9)	*t*	52		17	41	58	0	21	21	*t*	21		100
3,4-Benzpyrene (1.7)	18	82	100	41	59	100	6	23	29	18	18	36	100
1,12-Benzperylene (9.2)	31	66	97	67	33	100	5	15	20	11	13	24	100
Anthanthrene (2.4)	25	54	79	54	33	87	*t*	17		13	13	26	100
Coronene (10.0)	40	36	76	66	26	92	12	8	20	15	10	25	100

Although separation of the enriched small-sized soot from plasma was laborious, analysis for but a single carcinogenic hydrocarbon made the procedure relatively simple. In marked contrast, separation of large-sized soot from plasma was readily accomplished; however, analysis was more complicated because of the presence of several polycyclic aromatic hydrocarbons. In all instances, chromatography on a short column of activated alumina was necessary before accurate qantitation was possible.

Analysis for 3,4-benzpyrene was carried out with a Beckman DK-2 spectrophotometer. Fluorescence spectroscopy was used for the differentiation of 3,4-benzpyrene and 1,12-benzperylene. The plasma phase was similarly extracted, with ether as the solvent, and 3,4-benzpyrene quantitation was undertaken by the chromatographic and spectrophotometric methods described above. Control experiments were identical to the test ones except for the substitution of saline as the medium in the former.

After exposure to plasma proteins, the 3,4-benzpyrene remaining on the small-particle soot decreased slowly. After 3 days of incubation, 60 percent of the benzpyrene remained on the soot; and after 8 days, the quantity of 3,4-benzpyrene present dropped to 35 percent.

The elution pattern of the various aromatic polycyclic hydrocarbons from the large-sized carbon black (500 mμ) by plasma could readily be determined. Both the amounts eluted by plasma and the amounts retained on soot for the polycyclic aromatic hydrocarbons studied are shown in Table 1. Of the eight hydrocarbon compounds detected by the spectrophotometric technique, the following were found to be readily extracted by plasma: pyrene, fluoranthene, compound X, and 1,2-benzpyrene. The remaining identified polycyclic aromatic hydrocarbons in soot—3,4-benzpyrene, 1,12-benzperylene, anthanthrene, and coronene—were eluted at a lesser rate. Complete retention of 3,4-benzpyrene on the

soot particles was noted in the control experiments when saline was substituted for plasma.

In the course of incubations carried out for periods of from 3 to 192 hours, it was demonstrated that the degree of elution of polycyclic aromatic hydrocarbons from soot by plasma paralleled the elution of these compounds by nonpolar solvents (petroleum ether and ether) from activated alumina.

The carcinogenic implications of the elution of 3,4-benzpyrene from soot by plasma proteins warrant review. In urban air, pollutants have been shown to inhibit ciliary action so that abnormal deposition and retention of soot particles occur. Phagocytosis of soot particles occurs, and the elution of benzpyrene from the soot by the intracellular proteins results in abnormally high local concentration of desorbed polycyclic aromatic hydrocarbons, including 3,4-benzpyrene. An environment favorable to the biological activity of the carcinogenic hydrocarbons results.

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23 October 1957

Tests for Digestion of Algal Polysaccharides by Some Marine Herbivores

Although algae form the primary diet of many marine animals and digestion of some components of algae in the gut is apparent from an examination of the changes undergone during passage in the gut, it is of interest to know whether the enzymes of the gut, or of the glands attached to it, digest the algal constituents. Purification of some of the algal carbohydrates (*1*) has made it possible to study digestion of these substances by extracts of the gut wall. The gut extracts of three herbivorous forms in Monterey Bay were therefore tested for their ability to digest several algal carbohydrates.

In each case the gut, thoroughly washed with sterile sea water, was ground with sand in chilled buffer at a *p*H equivalent to that found in the gut as well as at *p*H values slightly to either side of it. After incubation of the extract and carbohydrate (under toluene) for a period of time which varied from 4 or 5 hours to 1 day, the quantity of reducing sugar released during digestion was tested by the Somogyi method (*2*). In all cases the blank, consisting of the sum of the reducing sugar of gut extract in buffer and of a mixture of the test carbohydrate in buffer, was subtracted from the reducing sugar found in the mixture of carbohydrate, extract, and buffer in which digestion was occurring. Because the rate of digestion is affected by temperature, preliminary tests were made to ascertain the optimal conditions for digestion when digestion of a substance occurred readily, and the same conditions were then provided in other cases.

Intestinal extract of the purple sea urchin, *Strongylocentrotus purpuratus,* proved incapable of digesting laminarin and fucoidin, although previous experiments (*3*) indicated its ability to digest iridophycin. A bacterial suspension from the gut of the urchin, however, digests the entire algae and their various constituents.

Puggetia producta, the kelp crab, while apparently omnivorous, eats algae in aquaria, when starved. Tests with extracts of its digestive gland showed it to have a potent amylase which quickly digests starch and glycogen but has no action on laminarin, fucoidin, agar agar, carragheenin, and a *Gigartina* polysaccharide. Failure to find positive results in these cases might have been due to improperly designed experiments, but the positive results obtained with *Cryptochiton* extracts on some of these polysaccharides, when similar techniques were used, makes it seem probable that the crab does not digest these constituents by virtue of its own enzymes if, indeed, these constituents are digested in its gut at all.

In the giant chiton, *Cryptochiton stelleri,* the digestive tract extract was found to have a very active amylase which readily digests starch and glycogen (*p*H 5.8 for the "stomach" extract and *p*H 6.8 for extract of the intestine). Tests showed that the chiton stomach extract digested the algal polysaccharides laminarin and fucoidin and that the extract of the intestine affected the first but not the second; digestion proceeded at a reasonable rate, comparable to that for digestion of starch and glycogen in some cases, somewhat more slowly in others. Since the action of the intestinal extract was less marked, tests with it were discontinued. However, the extracts of stomach were ineffective on cellulose, agar agar, iridophycin, carragheenin, and sodium alginate.

It is therefore possible that many of the algal constituents are not digested by herbivores and are passed out as part of the "roughage" of the diet. Certainly, when some marine herbivores are abundantly supplied with food in aquaria, they pass feces which contain many portions of ingested algae still colored and intact (*3*). They may therefore be able to use only the more readily available materials such as protein and floridean starch (in red algae), which are present in small amounts, necessitating intake of a large bulk of algae. However, young growing tips of algae contain a large percentage of proteins (*4*), and after feeding of proteins to some marine forms, the content of nonprotein nitrogen in their body fluid rises markedly (*3, 5*). On the other hand, it is also possible that bacteria in the gut of many marine herbivores digest constituents of the algae which the herbivore is unable to digest. While microbes capable of digesting various algal polysaccharides can be isolated from the gut and are sometimes present in large numbers (*3, 6*), they may occur as contaminants, and it is difficult to be certain that they perform this role. Even bacteria in the vertebrate rumen are able to digest some algal polysaccharides (*7*).

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16 December 1957

Book Reviews

The Economics of Nuclear Power. Including administration and law. Series VIII of *Progress in Nuclear Energy*. J. Gueron, J. A. Lane, I. R. Maxwell, and J. R. Menke, Eds. McGraw-Hill, New York; Pergamon, London, 1957. 513 pp. Illus. $17.

The International Conference on the Peaceful Uses of Atomic Energy, held at Geneva in August 1955, is unparalleled in the history of scientific conferences. It is unlikely that there can be a comparable conference in the foreseeable future; even the 1958 sequel which is now being planned is not likely to be of such significance. This conference marked the reopening of scientific communication in an area which had been largely classified for over a decade. The information collected and presented for the conference provides a base point for following and participating in future developments in the field of nuclear energy.

The series of publications entitled *Progress in Nuclear Energy* is based largely on the Geneva conference. The series has the benefit of an impressive editorial staff, representing leading figures in the field of nuclear energy throughout the world. The book *Economics of Nuclear Power* is the eighth volume in this series. Its contents actually are somewhat broader than the title may suggest. The book is divided into five chapters with selected papers on each of the subjects: "Needs and Resources," "Nuclear Power Economics," "Nuclear Fuel Cycles," "Reactor Programmes and Reactor Economic Data," and "Administration and Law."

The papers selected for each of the chapters listed above are selected primarily from those prepared for the Geneva conference. On the other hand, the editorial job was not merely one of selecting papers, nor are the papers selected strictly limited to those presented at Geneva. The book contains composite analyses of world-wide data on world energy requirements, taken from various sources, and of post-Geneva nuclear power economic data. The editors, in their selection of papers and in their preparation of special material, have tried to give perspective to a subject which is relatively new and which presents many problems that are as yet unsolved.

While the field of nuclear energy is developing rapidly and there is little experience on which to base judgments on the economics of nuclear power, the book must be considered as being of much more than historical significance. It is a useful reference book on the world energy situation and on the crucial technical and legal problems which must be solved in order for nuclear energy to become an important economic force.

The organization of material provides a continuity which is better than might be expected in a book composed of selected individual papers which were not written for continuity. There is unfolded a story of the importance of energy to man's industrial growth and improved standard of living, with an appraisal of energy resources which indicates that many countries already have inadequate resources of fossil fuels or hydro potential and many others look to a future within the next few decades in which new energy resources must be tapped. It is reassuring in this situation to learn that nuclear energy resources—uranium and thorium—already are known to be adequate to provide a basis for continued industrial expansion. This adequacy in terms of tons of raw material and potential energy content of that material is significant only if supported by suitable technological and economic prospects for utilization of the energy. The promising nuclear fuel cycles—involving both uranium and thorium raw materials—are well described in papers which reflect honest differences of opinion and different local circumstances. These differences in opinion and circumstances are also reflected in the summaries of reactor programs and reactor economic data.

One factor weakens the book in its endeavor to provide factual answers to the questions raised by its title but, at the same time, introduces a certain mystery which adds to the interest of those who are inclined to project into the future: authors of the selected papers and editors of the book were faced with total absence of operational experience in nuclear power plants designed specifically to optimize nuclear power economics. Nevertheless, there prevails an optimistic attitude that such plants, when built and operated, will become economically competitive and will provide a justification for rapid expansion in the nuclear power industry.

This projection of an expanding nuclear power industry clearly shows the importance of paying immediate attention to the administrative and legal aspects of nuclear energy. These administrative and legal problems are unique and complex as a result of the military importance of special nuclear materials and of the long-term potential hazards of the radioactive materials involved in the production of nuclear energy. The chapter on administration and law clearly identifies the problem areas and summarizes experience pertinent to their solution. One is left with the realization that there is much which remains to be done, not only in the development of technology for economic nuclear power but also in the education of the public and in the adaptation of national and international law to the new problems which its utilization imposes.

The fact that the book consists of a collection of individual papers has both advantages and disadvantages. Individual articles of special interest at a particular time can be singled out without concern about dependence upon previous articles. In this sense the book is a reference document which should be useful for some time to come. The fact that different attitudes of different authors from different countries are included also provides a good basis for the reader's own evaluation of what the future holds. On the other hand, the fact that the book relies almost entirely on the selection of articles for reproduction makes for a certain amount of unbalance in overemphasis of some situations and duplication of certain thoughts in several different articles.

The editors have done a commendable job in their selection of papers and in supplementing them with special commentary. The reader should be warned, however, that the principal subject of economics of nuclear power is one which requires continuing reappraisal and updating. With that word of caution, the book is recommended as a valuable addition to the library of anyone active in the energy field and interested in the possible role of nuclear energy in the future.

U. M. STAEBLER
U.S. Atomic Energy Commission

1001 Questions Answered About the Weather. Frank H. Forrester. Dodd, Mead, New York, 1957. 419 pp. Illus. + plates. $6.

This is an unusual book written in question-and-answer form. The 1235 items are organized in 12 chapters, which deal with the sun, the air-conditioned earth, thunderstorms, color in the sky, climates, applications, medical meteorology, weather lore, the weather services, history of weather studies, and how to be weather-wise.

The author appears to have engaged in an orgy of questions and answers and to have come out with a peculiar mixture of good and bad. For example, one is surprised to read, "What is humiture?" and relieved to find that it is "a nonscientific term" which indicates "the mean between temperature and humidity." There are many other questions and answers on this level.

The style is admirably calculated to catch the eye of the reader, but the reader, if he has any background at all, will catch the author in a number of inaccuracies, oversimplifications, and sweeping statements.

Certain sections, particularly those which deal with instruments and observations, everyday weather, and climate, contain much information of interest to laymen. The most pleasing part of the book is the chapter on the history of weather studies. Here the reader is taken from antiquity to the International Geophysical Year and reminded of many historical dates which are often lost in the rushed tempo of modern teaching.

It has been difficult to determine what audience the author had in mind. The book is dedicated to "Michael, who is too young to ask questions." In the foreword, written by Ernest J. Christie, it says that the book will be valuable in libraries, schools, and places of business and will be a useful reference for amateurs and professionals alike. Perhaps one may assume that the author knows best. Few will wish to read the whole book, but many will like to browse through parts of it.

SVERRE PETTERSSEN
University of Chicago

Edward Williams Morley. His influence on science in America. Howard R. Williams. Chemical Education Publishing Company, Easton, Pa., 1957. xi + 282 pp. Plates.

To the many who refer glibly to the Michelson-Morley experiment, the second name in the couplet has almost no association with a human being. Howard R. Williams has not only brought the man, Edward Williams Morley (1838–1923), out from behind the tag, but he has also discovered and thereby undoubtedly preserved a large body of manuscripts concerning him. One need not go all the way with Williams in considering Morley "the greatest chemist and pure scientist of his time" to see in this account a progression which has wide implications concerning the state of science in America in the last half of the 19th century.

From ministerial student to secondary-school teacher, to college preacher and professor of all scientific work at Western Reserve University, to self-educated chemist and industrial consultant, Morley, by the 1880's, steadily moved toward basic research. His determination of the atomic weight of oxygen was his *magnum opus*. If Williams is less enthusiastic about the obstacles and missed opportunities in Morley's career, he nevertheless shows them clearly. Morley's years of work on the analysis of air missed the inert gases. His collaboration with Michelson ended abruptly and left a sense of strain. The university thoughtlessly allowed his oxygen apparatus to be broken up while he was in Europe.

Because of the importance of the experiment, a more detailed assessment of Morley's contribution to the work with Michelson would be welcome. But Williams has well performed the rescue from oblivion of Edward W. Morley.

A. HUNTER DUPREE
University of California, Berkeley

Schedules of Reinforcement. C. B. Ferster and B. F. Skinner. Appleton-Century-Crofts, New York, 1957. vii + 741 pp. $6.50.

A "schedule of reinforcement" might be described as an experimenter's strategy, prescribing exactly how the administration of reinforcing stimuli, usually food or water, to an animal depends upon the animal's behavior over a period of time. Combining extraordinary ingenuity with apparently limitless resources in the way of electrical programming devices, Ferster and Skinner have devised means of duplicating in the laboratory virtually any kind of response-reinforcement contingency that one might expect to find in an animal's natural environment, and probably some that unautomatized nature has yet to try.

The microcosm upon which these investigators have imposed their schedules is a modified picnic icebox containing a pigeon and a food-dispensing machine. Whenever it pecks a lighted key on the wall of the box, the pigeon operates an automatic recorder and, upon occasion, the food-dispenser. Five years of intensive research have been devoted to obtaining a detailed description of the process whereby the pigeon adjusts its rate of key-pecking to prevailing schedules of reinforcement.

This description is transmitted to the reader, just as it comes from the pigeon, in the form of graphs representing cumulative responses versus time for individual animals. Even to the untrained eye these graphs will spell out some striking facts. An abundance of direct and unequivocal evidence establishes the fact that the pigeon can learn discriminations based on "clocks" (that is, stimuli that vary systematically with time) and on "counters" (stimuli that vary systematically with cumulative frequency of the pigeon's own responses over any designated interval). From these facts it is but a short inferential step to the conclusion that variations in rate of responding under various schedules are attributable to discriminative control of the response by temporal patterns of response-produced stimulation.

To psychologists this monograph will represent not simply a research report but also a tour de force in Skinner's long-standing campaign against some of the most deeply entrenched canons of experimental method and theory construction. It presents, in some 900-odd figures, perhaps 5 percent of the staggering quantity of raw data collected during the project; it reports scores of experiments, and it reveals the delicate and precise control that one may obtain over an animal's behavior, given sufficiently complete command of the animal's environment. But it includes no mention whatever of systematic criteria for sampling, no formal experimental designs, no measurement of error, no logical deductions from hypotheses, no statistical tests, no summarization of the fruits of experiment in the form of abstract laws or conceptual models.

By comparing the present volume with, say, C. L. Hull's *Essentials of Behavior*, one can see clearly the consequences of following either the extreme "intuitionist" or the extreme "formalist" in his approach to a science of behavior.

W. K. ESTES
Indiana University

Light Scattering by Small Particles. H. C. Van de Hulst. Wiley, New York; Chapman & Hall, London, 1957. xiii + 470 pp. Illus. $12.

The book is divided into three main parts. Part I is devoted to "Basic Scattering Theory," part II to "Special Cases of Particles," and part III to "Applications." The first two parts are very com-

plete and occupy 380 pages of a total of 453 pages. The last part is relatively short and, in the words of the author, "is meant to give only typical examples of practical problems in which the preceding theories have proved important." The three domains from which such examples are chosen are chemistry, meteorology, and astronomy. References to important literature are distributed lavishly throughout the book; it closes with a 5-page index of names and an 11-page subject index.

Characteristic of the book is the fact that the subject of light-scattering is treated exclusively from the "particle" point of view. This means that the discussion is deliberately limited to cases in which the scattering can be considered as a superposition of radiations emerging without interdependence from separate particles, whereas cases like the scattering by an inhomogeneous medium with local fluctuations of its optical properties are omitted from the discussion.

Within the range defined by these restrictions the treatment is excellent. In part I everything is said which is necessary to characterize the scattered light in the most general way. This will be evident from the titles of the two last chapters in this part: "Wave propagation in a medium containing scatterers" and "Polarized light and symmetry relations." Specifically, it is shown in this part how any scattering problem can be solved if the four components of a four-component matrix are known for each individual particle with a particular orientation in space. Part II, which occupies the main portion of the book, shows, for special types of particles, how to find these components and the simplifications which are possible in many cases. Here special attention is devoted to particles that are either very small or very large by comparison with the wavelength of the light. The classical case of spherical particles, in which a rigorous calculation (G. Mie) is possible for any ratio of the diameter to the wavelength and for any optical constants of the material of the sphere, is treated extensively. As a special case, a whole chapter is devoted to the "optics of a raindrop" and the theory of the rainbow. Part II closes with two chapters treating "Particles of other forms" and "Edge phenomena and surface waves."

In summary, this is a book which can be highly recommended to anyone who wishes to be informed about all the details and the sometimes surprising implications of the disturbing effects which particles have on the propagation of light. It is a book which is not always easy to read, but the effort involved in doing so is highly rewarded.

PETER P. DEBYE
Raytheon Manufacturing Company

The Terpenes. The triterpenes and their derivatives. vol. IV, *Hydrocarbons, Alcohols, Hydroxy-aldehydes, Ketones and Hydroxy-ketones.* The late Sir John Simonsen and W. C. J. Ross. Cambridge University Press, New York, 1957. ix + 524 pp. Illus. $13.50.

Progress in the elucidation of the structures of the triterpenoids has occurred mainly in the last 20 years and culminated recently in the establishment of the biosynthetic link between the triterpenes and the steroids. This volume by Simonsen and Ross represents a collection and critical survey of an already large and rapidly expanding literature. It would be welcome in any event but is the more so since the authors have been able to include the most recent advances in the understanding of the biosynthesis and stereochemistry of the triterpenes and closely related sterols.

The organization of the new volume follows that of its predecessors in the series, commencing with a brief description of the broad structural features of the triterpenes and progressing from the hydrocarbons to alcohols and polyfunctional triterpenes. Each compound is discussed within the classical framework of source, proof of structure, and chemical reactivity. Extensive use is made of infrared and ultraviolet absorption spectral data in support of the structure assignment, so that the work contains a wealth of valuable, general information of this sort.

Large as is the catalogue of triterpenes of established structure, the authors' listing of an almost equal number of compounds of unknown constitution gives promise of continuing activity in meeting the challenges presented by structure variations within the triterpenoid framework.

The large size of triterpene molecules has forced the extensive use of outline formulas in this most recent volume of the series. Most organic chemists will welcome this departure from earlier practice. However, some will take offense, and others may even be confused somewhat by the apparent disregard shown by the authors in this case for the beautiful geometric regularities of hexagons and pentagons.

The acknowledged interest and contributions of outstanding English chemists in the preparation of the volume gives assurance that the consistent effort to organize the literature on the terpenes which has been so successful in the hands of Sir John Simonsen will not cease with his death.

RICHARD H. EASTMAN
Stanford University

New Books

Thrombelastography. Mario de Nicola, Chauncey Leake, Ed. Thomas, Springfield, Ill., 1957. 120 pp. $5.50.

Elements of Modern Abstract Algebra. Kenneth S. Miller. Harper, New York, 1958. 196 pp. $5.

Economic Analysis and Policy in Underdeveloped Countries. P. T. Bauer. Commonwealth-Studies Center, Duke University Press, Durham, N.C. Cambridge University Press, London, 1957. 158 pp. $3.

The Spectrum of Atomic Hydrogen. G. W. Series. Oxford University Press, New York, 1957. 87 pp. Paper, $2.

Ordinary Difference-Differential Equations. Edmund Pinney. University of California Press, Berkeley, 1958. 274 pp. $5.

Archeological Investigations at the Mouth of the Amazon. Bulletin 167, Bureau of American Ethnology. Betty J. Meggers and Clifford Evans. Smithsonian Institution, Washington, 1957. 692 pp.

Finding Fossil Man. Robin Place. Philosophical Library, New York, 1957. 126 pp. $7.50.

An Introduction to Scale Coordinate Physics. An introduction to the formalization of the macro operational point of view. William Bender. Burgess, Minneapolis 15, 1958. 349 pp.

Louis Pasteur. A great life in brief. Pasteur Vallery-Radot. Knopf, New York, 1958. 212 pp. $3.

The Beetles of the Pacific Northwest. pt. II, *Staphyliniformia.* Publ. in Biology No. 16. Melville H. Harch in collaboration with Milton W. Sanderson and Gordon A. Marsh. University of Washington Press, Seattle, 1957. 393 pp. $7.

The Pharmacologic Principles of Medical Practice. A textbook on pharmacology and therapeutics for medical students, physicians, and the members of the professions allied to medicine. John C. Krantz, Jr. and C. Jelleff Carr. Williams & Wilkins, Baltimore, ed. 4, 1958. 1324 pp. $14.

Resources for the Future, Annual Report. For the year ending 30 Sept. 1957. Resources for the Future, Washington 6, 1957. 89 pp.

Trephine Technique of Bone Marrow Infusions and Tissue Biopsies. Henry Turkel. The author, 8000 W. Seven Mile Road, Detroit 21, ed. 8, 1957. 84 pp.

Rapport Annuel sur le Fonctionnement Technique. Année 1956. Institut Pasteur du Viet-Nam. Saigon, Sud-Viêtnam, 1957. 138 pp.

A Practical Guide to Plant Sociology. For foresters and agriculturists. F. R. Bharucha and W. C. DeLeeuw. Orient Longmans, Bombay, India, 1957. 46 pp.

Expert Committee on Malaria, Sixth Report. WHO Tech. Rept. Ser. No. 123. 84 pp. $0.60. *Joint FAO/WHO Expert Committee on Milk Hygiene, First Report.* WHO Tech. Rept. Ser. No. 124. 54 pp. $0.60. *Juvenile Epilepsy, Report of a Study Group.* WHO Tech. Rept. Ser. No. 130. 44 pp. $0.30. *Treatment and Care of Drug Addicts.* WHO Tech. Rept. Ser. No. 131. 19 pp. $0.30. World Health Organization, Geneva, 1957.

Meetings and Societies

Enzyme Chemistry

The first International Symposium on Enzyme Chemistry, organized by the Science Council of Japan and held under the auspices of the newly formed International Union of Biochemistry, was held in Tokyo and Kyoto, 16 to 23 October 1957. It was an excellent meeting, well attended by representatives from about 20 nations, including more than fifty scientists from the United States. This is reported to have been the largest international scientific meeting ever held in Japan.

The four major topics under consideration were: (i) group transfer mechanisms; (ii) hydrogen, oxygen, and electron transfer; (iii) formation of proteins and enzymes; and (iv) enzymes in industry. Nearly 1000 papers were presented within each of the four major categories. Four special papers were given by scientists from the U.S.S.R., Germany, the United States, and Japan. Since this was one of the few occasions during which a large number of representatives from the East and West have met for scientific discussions on enzymes, it is especially fortunate that the program allowed adequate time for comments on the papers presented. The *Proceedings*, which will include the written record of these discussions, will undoubtedly be of great interest to scientists in the field of enzymology.

In general, the Japanese have shown excellent progress in the purification of enzymes. (It is estimated that 20 percent of the national income of Japan is derived from industrial enzymology.) Cytochrome chemistry, particularly the demonstration of many highly purified or crystalline preparations, attests to their skill in this field. The Western countries, on the other hand, have pursued to a greater extent the study of reaction mechanisms, especially that of oxidative phosphorylation. The Russian delegation received considerable publicity; press reports stated that Russian scientists are "closest to finding the secret to the artificial creation of life."

Japan appears to be an unusually good location for truly international scientific meetings. The entertainment offered by the organizing committee was excellent; many scientists and their wives visited Japanese homes, national shrines, and Geisha teahouses. The Russian Embassy elaborately entertained in honor of the leader of their scientific delegation. The Communist Chinese delegation failed to arrive, and this was interpreted by some as a protest against the presence of the group from the Republic of China.

The United States scientists feel that a great deal of valuable information was obtained. In addition, many personal contacts with professors and students of Japanese universities were made or reinforced, and a much closer scientific relationship will be possible in the future.

BRITTON CHANCE
School of Medicine, University of Pennsylvania, Philadelphia

Forthcoming Events

March

25–27. Occupational Safety, President's Conf., Washington, D.C. (President's Conf. on Occupational Safety, U.S. Dept. of Labor, Washington 25.)

26–28. American Power Conf., 20th annual, Chicago, Ill. (Illinois Inst. of Technology, 35 W. 33 St., Chicago 16.)

27–29. American Physical Soc., Chicago, Ill. (E. R. Fitzgerald, Dept. of Physics, Pennsylvania State Univ., University Park.)

27–29. Mechanisms of Hypersensitivity, 8th internatl. symp., Detroit, Mich. (W. J. Nungester, Dept. of Bacteriology, Univ. of Michigan, Ann Arbor.)

27–29. National Science Teachers Assoc., 6th natl., Denver, Colo. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington 6.)

27–29. Optical Soc. of America, annual, Washington, D.C. (S. S. Ballard, Scripps Institution of Oceanography, San Diego 52, Calif.)

28. New Jersey Acad. of Science, 3rd annual, Newark. (H. L. Silverman, Nutley Public Schools, Nutley, N.J.)

29. South Carolina Acad. of Science, annual, Charleston. (Miss M. Hess, Dept. of Biology, Winthrop College, Clemson, S.C.)

29–30. American Psychosomatic Soc., 15th annual, Cincinnati, Ohio. (T. Lidz, 551 Madison Ave., New York 22.)

30–3. American College Personnel Assoc., annual, St. Louis, Mo. (L. Riggs, DePauw Univ., Greencastle, Ind.)

April

1. Microcirculatory Conf., 5th, Buffalo, N.Y. (S. R. M. Reynolds, Dept. of Anatomy, Univ. of Illinois College of Medicine, 1853 W. Polk St., Chicago 12.)

1–2. Alabama Acad. of Science, annual, Birmingham. (H. M. Kaylor, Dept. of Physics, Birmingham-Southern College, Birmingham.)

1–3. Corrosion Control, 5th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

2–4. American Assoc. of Anatomists, annual, Buffalo, N.Y. (L. B. Flexner, Dept. of Anatomy, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

2–4. Instruments and Regulators Conf., Newark, Del. (W. E. Vannah, Control Engineering, 330 W. 42 St., New York 36.)

3–5. Pennsylvania Acad. of Science, annual, Easton, Pa. (G. R. Stevens, Dept. of Geology and Geography, Lafayette College, Easton.)

4–5. Southern Soc. for Philosophy and Psychology, annual, Nashville, Tenn. (W. B. Webb, U.S. Naval School of Aviation Medicine, Pensacola, Fla.)

7–11. American Assoc. of Cereal Chemists, annual, Cincinnati, Ohio. (J. W. Pence, Western Utilization Research Laboratories, Albany, Calif.)

8–10. Electronic Waveguides Symp., New York. (J. Fox, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

9–12. National Council of Teachers of Mathematics, Cleveland, Ohio. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

9–14. Applied Psychology, 13th internatl. cong., Rome, Italy. (L. Meschieri, National Inst. of Psychology, Rome.)

10–11. American Inst. of Chemists, annual, Los Angeles, Calif. (L. Van Doren, AIC, 60 E. 42 St., New York 17.)

10–12. Biometric Soc., ENAR, Gatlinburg, Tenn. (T. W. Horner, General Mills, Inc., 400 Second Ave. South, Minneapolis 1, Minn.)

10–12. National Speleological Soc., annual, Gatlinburg, Tenn. (G. W. Moore, Geology Dept., Yale Univ., New Haven, Conn.)

10–12. Ohio Acad. of Science, annual, Akron, Ohio. (G. W. Burns, Dept. of Botany, Ohio Wesleyan Univ., Delaware, Ohio.)

11. Vitamin B-12 Symp., New York, N.Y. (Miss J. Watson, 451 Clarkson Ave., Brooklyn 3, N.Y.)

11–12. Eastern Psychological Assoc., annual, Philadelphia, Pa. (G. Lane, Dept. of Psychology, University of Delaware, Newark.)

11–12. Montana Acad. of Sciences, annual, Missoula. (L. H. Harvey, Montana State Univ., Missoula.)

11–18. Horticultural Conf., 15th internatl., Nice, France. (Secretariat General, 84, rue de Grenelle, Paris 7°, France.)

12. Society for the Scientific Study of Religion, New York. (L. Whitman, 297 Fourth Ave., New York, N.Y.)

(*See issue of 21 February for comprehensive list*)

LETTERS

The editors take no responsibility for the content of the letters published in this section. Anonymous letters will not be considered. Letters intended for publication should be typewritten double-spaced and submitted in duplicate. A letter writer should indicate clearly whether or not his letter is submitted for publication. For additional information, see Science **124**, *249 (1956) and* **125**, *16 (4 Jan. 1957).*

Hungarian Scientists in the United States

December 1957 marks the first anniversary of the arrival in the United States of America of many Hungarian scientists from Austria, Yugoslavia, and other countries as a result of the Hungarian freedom fight.

On this occasion we want to thank the National Academy of Sciences, which understood our problems and came to our aid in finding homes and jobs for us in the New World. The Academy initiated a program of professional placement of scientifically qualified persons among the refugees. Between 19 Dec. 1956, and 1 May 1957, the Academy assisted more than 750 of the Hungarian scientists at Camp Kilmer. Between 1 May and 8 December the Academy had an office in Brooklyn, New York, which helped several hundred more Hungarian refugees to find professional positions in this country. In March the Academy sent a special mission to Vienna to help us, and in August it sent another mission to Yugoslavia.

Through the Academy's program most of us have found work in our own fields, and the program continues for the few people who have not found suitable work and for the other few refugees who are still arriving in the United States. The Academy has given some of us study courses in English to help us in our new positions. The majority of the scientists have been placed in positions where they can continue their research work or further their education.

On this anniversary the many refugee scientists from Hungary wish to thank the National Academy of Sciences and the many universities, institutes, research laboratories, and industrial companies for their wonderful help. We all hope that our temporary home will become our permanent home, and we hope to prove our worthiness.

MANUELA KOGUTOWICZ
Washington, D.C.

On the Vitalistic-Mechanistic Controversy

I have discovered a "new" kind of bird. It has fur and mammary glands and most people call it a mammal but that is just because of their ignorance and prejudice. "The idea" of a bird which suckles its young "is altogether new. But it is of outstanding importance, and *we must become used to it*" (italics mine). Sounds silly, doesn't it? However, it is simply a paraphrase of Koch's [*Sci. Monthly* **85**, 254 (1957)] quotation from Bronowski on the "new" kind of machine which "covers all the basic actions of living things, from the search for food in the lowest cell to the boldest creations of the human imagination" and which everyone else calls a "living thing."

Therefore, while we can take consolation in the fact that the author's "justifiable conclusion [page 255] seems to be that the vitalistic-mechanistic controversy, in its original formulation, is now almost meaningless for scientists," nevertheless I don't believe that calling a living thing by a new name—"predictor"—changes its nature one iota. "A rose by any other name. . . ."

Finally, with what "*testable* standards" (italics mine) does the author (page 255) propose to "fetter" the flight of the poet or the brush of the artist?

P. H. YANCEY
Department of Biology, Spring Hill College, Mobile, Alabama

Father Yancey's paraphrase, perhaps, was meant to ridicule Bronowski's estimate of the great importance of the idea of an organism as a predictor. However, his choice of a bird with fur and mammary glands as an altogether new idea hardly makes an effective analogy. Yancey's argument does sound silly because it is so patently false. The monotrematous mammal has been known to exist for a long time, and the duckbill is listed in all encyclopedias and dictionaries. Its Latin name, *Ornithorhynchus*, clearly refers to its birdlike characteristics.

Presumably, Father Yancey has no logical arguments with which to refute my conclusions and so has used a stratagem with which he hopes to sidestep the basic issues on which we have differing opinions. In his essay on "The Origin of Life" [*Bios* **23**, 212 (1952)], he concluded that the idea of emergent evolution "does not differ essentially from spontaneous generation," and that this in turn is nothing more than "the development of life from non-life by chance."

Modern theories of evolution entail the transactional relationship of causal patterns as well as of random factors, and the process giving rise to protoplasm is not believed to have recurred in later geological periods of the earth's history. It is apparent that Yancey prefers to argue logically only when he can make the initial assumptions.

Thus, having made the assumption that God's words, as recorded in the Bible, are the absolute truth, one cannot be surprised that he is able to prove to himself that God "endowed matter with the power to develop into more and more complex forms until, when capable of supporting what we now call 'life,' this would emerge from a 'seminal reason' that He had implanted there in the original creation" [*Bios* 23, 215 (1952)].

I heartily agree with my critic that the nature of a material object is utterly independent of the language which we may apply to it, even when the language comes from the Christian Bible, or from St. Augustine.

Finally, Yancey imputes that I propose to fetter the flight of the poet and the brush of the artist with testable standards. In my article [*Sci. Monthly* **85**, 246 (1957)] I specifically stated that I do not deny the importance of such truth as might be embodied in a great painting or a musical composition; I am happy to add to these the flight of the poet. But my original conclusion still stands. These subjective aspects of truth will never be as reliable a guide for behavior and belief about objective phenomena as scientific inquiry. And I believe this is especially true in the field of morality or values.

It is curious that some vitalists assume that scientific theory is based on rigid determinism, whereas others make the accusation that it is based on chance alone. The two ideas are directly contradictory and are both false. But of course, the dissociation is convenient, and so the hapless scientist is assumed to be a mechanist when the question concerns the nature of life [*Bios* **23**, 7–25 (1952)] and a believer in chance alone, as above, when it is the origin of life that is under discussion.

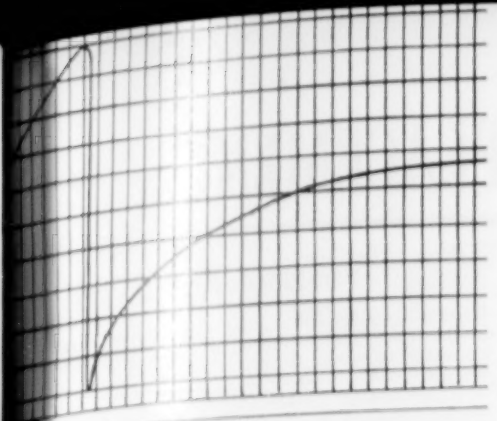
LEO F. KOCH
Department of Biology, University of Illinois, Urbana

Cancer Research

In the issue of *Science* for 20 December [**126**, 1283 (1957)], I noted that a board of scientific counselors has been appointed to pass upon and to direct cancer research at the National Cancer Institute.

The fields of interest represented by these men are virology, surgery, pharmacology, medicine, radiology, and physical chemistry. In view of the fact that the genetics of cancer has been so brilliantly represented in cancer research at Bethesda, and since genetics plays a role in many cancers in man, I suggest that a geneticist in the field of cancer research should be added to this board.

MADGE T. MACKLIN
Ohio State University, Columbus



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EQUIPMENT NEWS

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to* Science, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

■ AUTOMATIC RECORDING REFLECTOMETER measures reflectance as the ratio of light in a test beam relative to that in a comparison beam. The instrument is capable of measuring whiteness, degree of yellowness, flashing and fading, amount of blueing, and other factors. (Gardner Laboratory, Inc., Dept. S915)

■ PULSE GENERATOR provides repetition rates from 1 cy/sec to 10 Mcy/sec. Pulse durations are variable from 0.02 μsec to 12.5 μsec. Rise time is 8 mμsec. Positive and negative pulses of 40-v amplitude are simultaneously available. Internal impedance is 185 ohm. (Rutherford Electronics Co., Dept. S920)

■ MECHANICAL VACUUM PUMP is designed for portability. Vertical design eliminates the usual belt-and-pulley drive and makes the pump leakproof. Free-air displacement is 50 lit/min with a guaranteed absolute pressure of 0.1 μ. (Arthur F. Smith Co., Dept. S921)

■ MULTIPLIER PHOTOTUBE is sensitive to red and near-infrared radiation. The spectral response covers the range 4200 to 11,000 A; maximum response is at about 8000 A. The tube uses a semitransparent cathode of 1.24-in. minimum diameter on the inner surface of the face end of the bulb. Time resolution is such that an input pulse having a duration of 1 mμsec or less will produce an anode pulse of about 5-mμsec spread, measured at 50 percent of maximum pulse height. The transit-time spread can be reduced to 2 mμsec by restricting the sensitive area. (Radio Corporation of America, Dept. S922)

■ ELECTRIC THERMOMETER, manufactured by Elektrolaboratoriet, Copenhagen, Denmark, operates on the thermocouple principle. Automatic compensation for ambient temperature eliminates the necessity for temperature control of a reference thermocouple. A variety of applicators adapt the instrument to a wide range of physiological temperature measurements. All applicators are adjusted so that they are ready to use and are standardized for replacement. The galvanometer-indicator scale length is 250 mm. Standard temperature range is 16° to 46°C, divided into intervals of 0.1°C. (Chemical and Pharmaceutical Industry Co., Inc., Dept. S923)

■ PHOTOGRAPHIC SENSITOMETER provides a gray-scale exposure for test of photosensitive materials. Pushbuttons select exposure times of 0.01, 0.001 and 0.0001 sec. Repeatability from flash to flash is within ±5 percent, and uniformity of light across the exposure plane is within ±2 percent. Color quality is that of daylight. Filters can be added to approximate a tungsten source. (Edgerton, Germeshausen and Greer, Inc., Dept. S924)

■ RESISTANCE WELDER permits welding of components directly to printed or etched wiring boards. Series-type welds, two simultaneous welds from one side of the work, can be made. The twin upper electrode arms are electrically independent and are continuously adjustable for pressure settings up to 25 lb. The equipment is self-contained. (Weldmatic, Dept. S919)

■ PITCH-YAW INDICATOR provides potentiometer output linear with angles of pitch and yaw. Ranges up to 27.5 deg are available with indicating accuracy of 0.1 deg. High-temperature components are used to permit operation at high Mach numbers. (Edcliff Instruments, Dept. S918)

■ ACCELERATION AND VELOCITY TRANSDUCERS of peak-reading type measure the plastic deformation of a metal sphere caused by a movable-piston mass. Available ranges are from 0 to 2000 and 0 to 50,000 *g*. Accuracy is ±5 percent over most of the range. (Avionic Products Engineering Corp., Dept. S916)

■ TACTILE COMMUNICATION SYSTEM, the "Teletac," is offered to provide the deaf with additional means of instant communication. The basic system consists of a single apparatus whereby the five fingers of the "speaker" press vibration-sending piano-type keys and the five fingers of the listener rest on corresponding sensitive receiving diaphragms. The speaker portion measures 6 by 10 by 2 in., the listener portion 8 by 9 by 2 in. The problem of optimum coding for use with the device remains to be solved. (Ramo Wooldridge Corp., Dept. S927)

■ BALANCE of semiautomatic, single-pan type may be used for weights from 0.1 mg to 200 g. The unit is of two-beam design; initial rough weighing is done on one beam, and over- or under-weight is indicated by signal light; final weighing adjustments are made automatically on a fine-weighing beam. Wear of the knife-edge is said to be reduced as a result. The optical-lever optical system used for indication projects an image of 10,000 divisions, each representing 0.1 mg. (Torsion Balance Co., Dept. S929)

■ COMPUTING INDICATOR displays two independent variables and a third variable which is a function of the two. Two direct-current reflecting galvanometers project lines extending across the screen of the indicator. One, a horizontal line, moves vertically in proportion to current, the other, vertical line, moves horizontally. The screen carries a family of curves representing a function which is read from the intersection of the two lines. (Aero Electronics Co., Dept. S933)

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